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MACROECONOMIC EFFECTS OF PUBLIC HEALTH EXPENDITURE IN THE UNITED STATES

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Abstract. In this paper, we provide an empirical framework to analyze the macroeconomic effects of public health expenditure in the US. In particular, a computable general equilibrium (CGE) model called GTAP-HE, has been developed and applied to include predicted variations in public health expenditure. Although the framework employed in the paper is highly specialized and may not hold generally, results provide relevant information on the relationship of health public expenditure and macroeconomic effects. Our main findings show that an increasing public expenditure is associated with a decrease in GDP and welfare and a positive effect on trade. We also find an increase in employment level in non-market services sector, which includes health, defense, education and public administration. The robustness of the results has been tested over time for the period 2010-2018. The main policy recommendation that can be drawn from the results is that the health expenditure policy needs to be coupled with labour and trade policies.

JEL Classification Numbers: D58, H51, I11.

Keywords: public health expenditure; computable general equilibrium; welfare decomposition.

1. Introduction

The interactions between health care expenditure and the remainder of the economy are multiple and complex. On the one hand, changes in income affect the consumption and the provision of health care; on the other hand, changes in health by variations in health care expenditure affect the well-being of populations, such as employment, productivity and income. The interdependencies between health care, health and the rest of the economy have been widely studied in the economic literature. [1] The traditional empirical approach used in these studies relies deeply on econometric models, that focus on multiple linkages between health expenditures and economic growth. Differently, this paper is a first attempt to analyze the general equilibrium effects of changes in public health expenditure, which aspects have been neglected in literature. In fact, there is a limited number of studies on computable general equilibrium (CGE) models in this application area, that have been mainly concentrated on coupling health and CGE models (see for example, Lee and McKibbin [24], Dixon *et al.* [16], Smith *et al.*[29]). Only recently, Bosello *et al.*[12] and Rutten and Reed [27] report some results of the effects on health expenditure using CGE models, but the aims of their studies differ from the aim of this paper. In fact, Bosello *et al.*[12]study the economic impact of climate change induced change in human health as change in labour productivity and demand for health care. Rutten and Reed [27] determine the macroeconomic impacts of change in health care provision under the assumption of different resource allocations.

The main contribution of our paper is empirical. It tries to offer policy recommendations taking as case study the US. We analyse the effects of change in public health expenditure on macroeconomic indicators, such as employment, GDP, trade and welfare, over a full projection period (2010-2018). For this, a computable general equilibrium (CGE) model, called GTAP-HE, has been developed to include the predicted variations in the public health expenditure. Data from

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[1]Bhargava *et al.* [2], Bloom and Canning [7], Bloom *et al.* [8]-[9]-[10], Crémieux *et al.* [14], Hamoudi and Sachs [17], Hitiris and Posnett [19], Jamison *et al.* [20], Knowles and Owen [23], Pritchett and Summers [26], Strauss and Thomas [30], Stronks *et al.* [31] and Thomas [32].

the National Health Expenditure Accounts (NHEA) for 2010-2018, computed by the Department of Health and Human Services have been used to simulate the scenarios.

Although the framework employed in the paper is highly specialized and may not hold generally, results provide relevant information on the relationship of public expenditure and macroeconomic effects. In fact, if on the one hand, on a microeconomic point of view, public health expenditure is usually sustained in order to increase the health service coverage and the health system resources, as well as to reduce inequities in health care, mortality and risk factors. On the other hand, in macroeconomic terms, an increase of public health expenditure may have negative effects on welfare and GDP. The main policy recommendation that can be drawn from the results is that the health expenditure policy needs to be coupled with labour and trade policies.

The structure of the paper is as follows. Section 2 explains the modeling framework. Section 3 presents scenarios and data set. Section 4 discusses the simulation results. The final section concludes and suggests directions for future research.

2. Modeling framework

In order to assess the macroeconomic effects of public health expenditure in the US, a computable general equilibrium (CGE) model, called GTAP-HE, has been developed and applied.

CGE models build upon general equilibrium theory that combines behavioral assumptions on rational economic agents with the analysis of equilibrium conditions. Since the first CGE application by Johansen [21], CGE models have been widely employed by various national and international organizations (IMF, World Bank, OECD, etc.), research institutions and universities. For survey articles see, e.g. Bhattacharyya [3], Bergman *et al.* [4], Borges [11], Conrad [13], Shoven and Whalley [28]. In order to analyze the impact of a policy change, the CGE modelers use the comparative methodology. Initially, the CGE model is developed such that its equilibrium replicates the transactions observed in the data. This procedure, called calibration, refers to the estimation of structural parameters of the model, based on available information on prices and quantities, normally, obtained from a Social Accounting Matrix (SAM). Moreover, the policy change is simulated by altering the relevant parameters and calculating the new equilibrium.

GTAP-HE is a refinement of the GTAP model, which is a comparative static, multi-commodity, multi-region CGE model with the assumptions of perfect competition and market equilibrium (Hertel [18]). The original GTAP model has been widely used and modified for analyzing the impacts of economic growth (Jorgenson [22]), international trade (Devarajan *et al.* [15]; Markusen et al., [25]) and environmental policies (Berrittella *et al.* [6]). We apply GTAP-HE by aggregating the US's economy into five industries (Table 1): Agriculture, Energy, Market Services, Non-market Services, Other Industries. Commonly to the standard GTAP, industries are modeled through a representative firm minimizing costs and taking prices as given. The production functions are specified via a series of nested constant elasticity of substitution (CES) functions such that:

$$y_i = (\sum_{j=1}^{n} \theta_j x_j^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where y_i is the production of the good i, x_j is the input j, θ_j is a weighting parameter, with $\sum_j \theta_j = 1$, and σ is the elasticity of substitution.

Each primary factor (Labor, Capital, Land and Natural Resources) is supplied to industries from its fixed regional endowment. Labor and capital are perfectly mobile endowments earning the same market return. Land and natural resources are sluggish endowments to adjust and, hence, they sustain differential returns in equilibrium. Domestic and foreign inputs are not perfect substitutes, according to the so called "Armington assumption" (Armington [1]), which accounts for product heterogeneity.

A representative household receives income, which is used to finance three classes of expenditure: private consumption, public consumption and savings. Her utility function is specified by a Cobb-Douglas structure. A constant-difference-elasticity (CDE) utility function is used for determining private consumption. Public consumption is determined by the maximization of a Cobb-Douglas utility function. However, almost all public expenditure is concentrated in one specific industry: Non-market Services. Both public and private consumption is split in a series of alternative composite Armington aggregates.

All these elements are linked by the concept of equilibrium, which is satisfied under the following properties: (i) supply equals demand for each produced good or service; (ii) supply equals demand in each factor market.

In GTAP-HE, the impact of public health expenditure is modeled by means of changes in the structure of public consumption. In more details, the affected variable is the public domestic expenditure of non-market services, as the health industry is a sub-industry of non-market services. Using the *linearized representation*, in the original GTAP model, the percentage change in public domestic demand is given by:

$$qgd_i = qg_i + \mu_i(pg_i - pgd_i) \tag{2}$$

where qgd_i is the public demand for domestic commodity i, qg_i is the public demand for commodity i, μ_i is the elasticity of substitution between domestic and imported goods, pg_i is the public consumption price for commodity i and pgd_i is the public consumption price for domestic commodity i.

Since consumption levels, including those of non-market services are endogenous variables in the original GTAP model, following the lead of Bosello *et al.*[12], we introduce a shift parameter in GTAP-HE, which yields the required exogenous change in public health expenditure if all prices and income levels would stay constant. Thus, the percentage change in public domestic demand becomes:

$$qgd_i = agd_i + qg_i + \mu_i(pg_i - pgd_i) \tag{3}$$

where agd_i is the exogenous change of the public demand for domestic commodity i.

When these shocks agd_i are simulated in a general equilibrium framework, the model allows the US's economy to adapt to the shocks. Furthermore, in order to comply with budget constraints and the Walras's law, public expenditure shares in other sectors are rebalanced, by means of counteracting reductions for consumption items not related to health. This does not affect the equilibrium interpretation of the shocks on expenditures for non-market services.

3. Design of scenarios and data

We use data from the National Health Expenditure Accounts (NHEA) for 2010-2018, computed by the Department of Health and Human Services with the aim of measuring the total amount spent in the United States to purchase health care goods and services during the year. This data are particularly suitable for our purpose since the NHEA contains all of the main components of the health care system within a unified structure and it also provides the source funding these expenditures. The NHEA bring into focus the share and magnitude of public and private spending for various range of health expenditure providing also projections of what health care expenditures will be in future.[2] In this paper we focus on public health expenditure, that is the annual percent change from previous year of Federal and StateLocal health spending including both Medicaid and Medicare. Table 2 reports the scenarios, that is the variation in public health expenditure over the full projection period 2010-2018.

[2]Projections are based on NHEA historical data and are estimates of spending for health care in the U.S. over the next decade by type of service delivered (hospital care, physician services, etc.) and by source of funding (Keehan *et al.* [**?**].

The approach to simulate the scenarios is based on a two-stage procedure. Firstly, counterfactual equilibria of the world economy are generated by "pseudo-calibration" from 1997 over the full projection period (2010-2018). This entails changing the initial calibration data in the model to forecasted values of some key economic variables for the projection period. The calibration data comes from the GTAP database, version 5, that contains the 1997 world economy data. The forecasted values for the projection period include estimates of population growth, endowments change of labour, capital and natural resources, productivity change of labor and land. The resulting scenario is called "benchmark".[3] Subsequently, conventional comparative analysis of public health expenditure in the US is conducted simulating the scenarios over the full projection period (2010-2018).

4. Simulation results

This section reports the macroeconomic effects of the public health expenditure in the US in terms of variations from the benchmark equilibrium over the full projection period (2010-2018).

Table 2 shows that shifts in public domestic demand for non-market services are slightly different before and after the simulations. This is due to the general equilibrium effects: the initial variation is higher than the expenditure variation observed in equilibrium, because the US's economy reacts to these shifts in non-market services demand by means of adjustments in price and income levels, which allow the system to attain a new general equilibrium.

Although, the public health expenditure in US increases, the final effect on the public expenditure is negative (Table 3). In fact, higher public demand for health induces to decrease the public demand on other consumption items.

Production level increases only for non-market services due to the increase of public health expenditure (Table 4). This yields an increase of employment in non-market services increases (Table 3). As supply of primary factors is fixed in the short run, a demand shift towards labour-intensive services, such as health, implies that the final effect on wages is positive (Figure 1). Furthermore, the production shift to labour-intensive sectors implies a reduction in import. The coupling of the decrease in import of non-market services with the substantial increase of exports by other industries yields positive effects on trade balance (Table 5). However, this would lead to a negative welfare change (Figure 2). Decomposing the welfare change in its components, Figure 2 shows that contribution of terms of trade to welfare change (expressed in terms of equivalent variation) is decreasing, and contribution of allocative effects to welfare change is increasing over time. This is due to the endowment distribution change. The effect of public health expenditure on GDP is negative, but it is not too much significant (Figure 3).

Comparing the results over the full projection period (2010-2018), in terms of magnitude, the relative ranking of the initial shocks does not always coincide with the relative ranking of GDP, welfare and trade. This is due to the fact that public health expenditure growth is not linear to the forecasted values for population growth, endowments and productivity change applied for the "pseudo-calibration" (or benchmark) scenarios. Furthermore, the main policy recommendation that can be drawn from the results is that in order to reduce the welfare and GDP loss, the health expenditure policy needs to be coupled with labour policy that affect the endowment distribution such that to reduce slightly the increase of employment in labour-intensive sectors, and trade policy, that decreases further the import tariffs.

5. Discussion and conclusions

This paper has attempted to discuss preliminary results on the macroeconomic effects of public health expenditure in the US. A multi-country, multi-region CGE model, called GTAP-HE, has

[3]These estimate values have been previously used for analyzing different policy issues, such as sustainability (Zhang *et al.*[33]) and public investment (Berrittella [5])

been developed to include the predicted variation in public health expenditure. On a microeconomic point of view, public health expenditure is usually sustained in order to increase the health service coverage and the health system resources, as well as to reduce inequities in health care, mortality and risk factors. However, the results in this paper suggest that there is a linkage between macroeconomic and health indicators that must be taken into account in evaluating health policy. But, in macroeconomic terms, an increase of public health expenditure have negative effects on welfare and GDP. These effects could be reduced by coupling trade and labour policies to health expenditure policy.

The GTAP-HE model employed in the paper may become particularly relevant for health policy if it is applied in developing countries. However, the GTAP-HE model suffers from a number of drawbacks and research on this topic merits to be extended to include at least four issues in GTAP-HE. Firstly indicators related to health service coverage, the health system resources, inequities in health care, mortality, burden of disease and risk factors. Secondly, health models, such that to obtain an integrated health assessment. Thirdly, determinants of health demand, that may affect labour supply, productivity and population level. Finally, intragroup income distributional change; in fact, any analysis of the impact of any health policy scenario should take into account it, because health impacts are likely to affect many socioeconomic groups at varying degree.

Appendix A. Parameters' estimates

Table 1. Industry aggregation

Industry	Sectors
Agriculture (Agr)	Paddy rice, Wheat, Cereal grains, crops, Vegetables, fruit, nuts, oil seeds, sugar cane and beet, plant-based fibres, Cattle, sheep, goats, horses, animal products, Forestry, Fishing
Energy (Energy_Ind)	Coal, Oil, Gas, gas manufacture and distribution, Petroleum, coal products, Electricity, Energy Intensive Industries (Minerals, chemical, rubber, plastic products, mineral products, ferrous metals, metals)
Market Services (MServ)	Construction, trade, surface transport, sea transport, air transport, communication, financial services, insurance, business services, dwellings, recreation and other services
Non-market Services (NMServ)	Public administration, defence, health and education
Other Industries (Oth_Ind)	Raw milk, wool, silk-worm cocoons, meat, vegetable oils and fat, dairy products, processed rice, sugar, food products, beverages and tobacco products, textiles, wearing apparel, leather products, wood products, paper products, publishing, metals products, motor vehicles and parts, transport equipment, electronic equipment, machinery, manufactures, water distribution services

Table 2. Public domestic demand for non-market services (% change w.r.t. benchmark scenario)

	Initial variation	Equilibrium
2010	5	4.948
2012	6.9	6.831
2014	7.4	7.328
2016	7.9	7.825
2018	8.2	8.125

TABLE 3. Social indicators (% change w.r.t. benchmark scenario)

	Public expenditure	Public expenditure as % of GDP	Employment in non-market services
2010	-0.0233	-0.0228	1.59
2012	-0.0306	-0.0304	2.20
2014	-0.0311	-0.0309	2.37
2016	-0.0315	-0.0307	2.54
2018	-0.0313	-0.0307	2.65

TABLE 4. Production levels ((% change w.r.t. benchmark scenario))

	2010	2012	2014	2016	2018
Agriculture	-0.18	-0.27	-0.30	-0.33	-0.36
Energy	-0.06	-0.09	-0.09	-0.10	-0.11
Market Services	-0.40	-0.56	-0.59	-0.63	-0.66
Non-market Services	1.64	2.28	2.45	2.62	2.73
Other industries	-0.41	-0.58	-0.63	-0.68	-0.72

TABLE 5. Terms of trade (Mln $ change w.r.t. benchmark scenario)

	2010	2012	2014	2016	2018
Agriculture	149	239	292	349	402
Energy	818	1262	1487	1714	1919
Market Services	596	857	938	994	1034
Non-market Services	-28	-57	-83 -	116	-147
Other industries	2558	3725	4166	4561	4910
Total	4093	6027	6800	7501	8119

FIGURE 1. Wages (% change w.r.t. benchmark scenario)

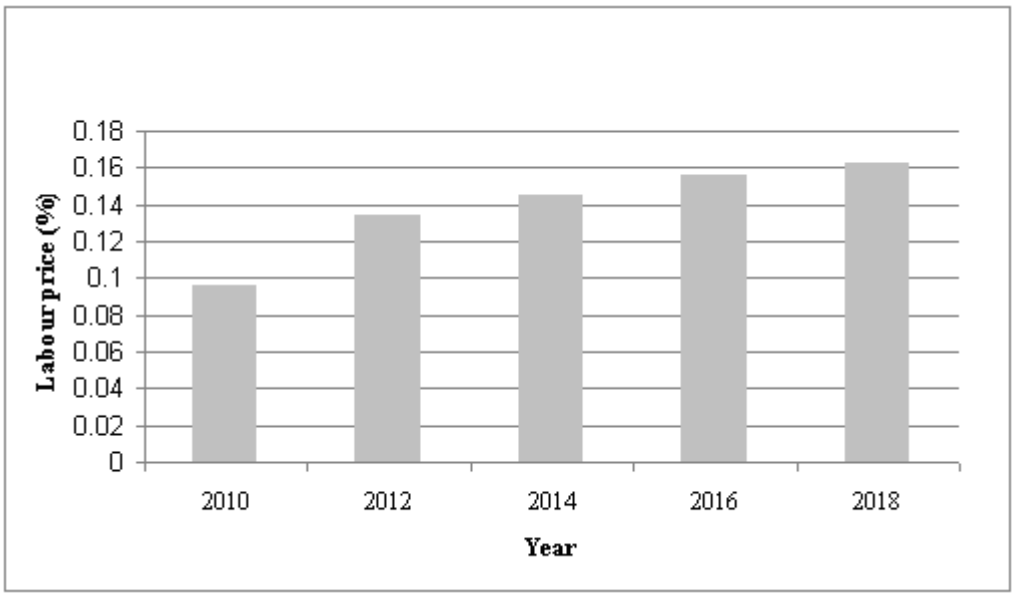


FIGURE 2. Welfare effects (Mln $ change w.r.t. benchmark scenario)

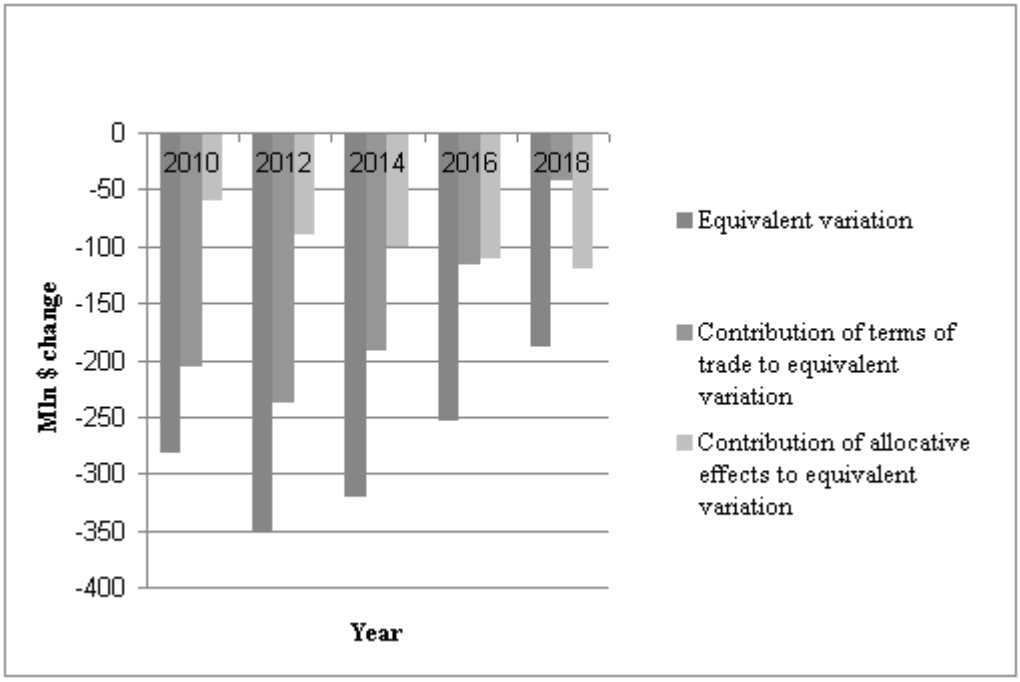
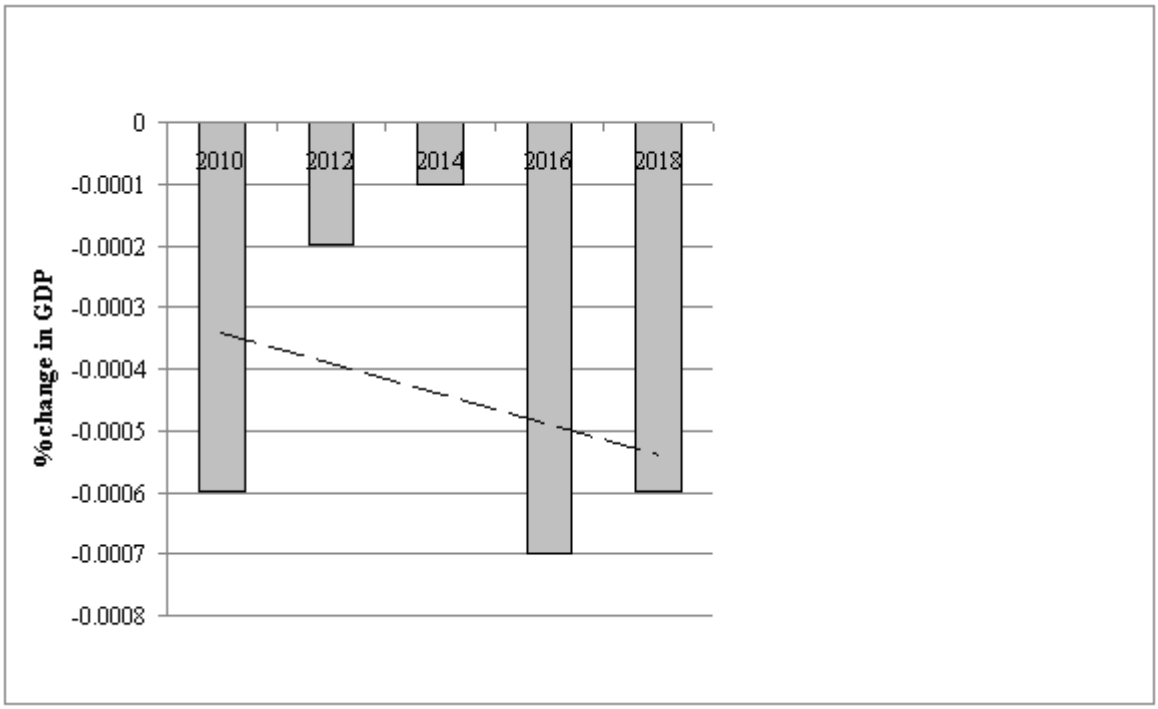


FIGURE 3. Change in GDP as function of the change in the public health demand ((Mln $ change w.r.t. benchmark scenario))



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