PERSPECTIVAS

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Sumario

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PERSPECTIVAS

Revista de Análisis de Economía, Comercio y Negocios Internacionales

Presentación

PERSPECTIVAS: Revista de Análisis de Economía, Comercio y Negocios Internacionales es una publicación semestral cuyo objetivo principal es la difusión de artículos académicos de alto rigor teórico y metodológico, abarcando temas sobre distintos campos de la teoría económica, el comercio y negocios, permitiéndose también la divulgación de artículos de discusión y aplicaciones que enriquezcan el pensamiento económico y/o contribuyan a la consolidación de la utilización de técnicas económicas en el entorno actual. Su misión es ser referencia para investigadores, estudiantes e interesados en cuanto a temas contemporáneos y discusiones actuales en la economía, así como crear un espacio para dar la bienvenida a autores de los sectores público y privado con el fin de vincular el estudio y la práctica de esta disciplina.

La cobertura temática de la revista es multidisciplinaria en cuanto a los ejes fundamentales que se mencionan en el título, aunque principalmente se enfoca en las siguientes áreas:

- Microeconomía teórica y aplicada.
- Macroeconomía teórica y aplicada.
- Econometría.
- Teoría económica.
- Economía internacional.
- Matemática económica (Teoría de juegos, economía dinámica, optimización).
- Finanzas.
- Comercio internacional.
- Regulaciones internacionales.
- Organización industrial.

Así mismo, la revista está dirigida hacia economistas, profesionales en los negocios, comercio internacional y política pública, actuarios, administradores y profesionistas en matemática aplicada a las ciencias sociales.
En esta ocasión, *PERSPECTIVAS: Revista de Análisis de Economía, Comercio y Negocios Internacionales* presenta a sus lectores el contenido del Volumen 14 (1) correspondiente al período julio-diciembre 2021.

En el presente volumen de Perspectivas se presentan cuatro trabajos de investigación, todos ellos desde la perspectiva de la modera teoría económica. Los tres primeros pueden inscribirse en el marco de la teoría de la economía pública desarrollada a partir de los 70, sobre la base de la microeconomía moderna. Los dos primeros trabajos del grupo hacen referencia a la existencia de fallos de mercado y la necesidad de la participación del Estado para lograr un crecimiento balanceado y eficiente.

El trabajo titulado "Provisión de un bien de mérito por agencias gubernamentales jerárquicas: medicamentos para la diabetes en Argentina" analiza la necesidad de la participación del Estado en el suministro de los bienes denominados de mérito o preferenciales, bienes que tienen un alto impacto en el bienestar social y cuyos altos costos impiden el acceso a diferentes grupos sociales que requieren dichos bienes, lo que repercute fuertemente en la productividad y en el desarrollo económico del país. Por su parte, "Desarrollo sostenible y valoración intertemporal: un enfoque teórico" analiza las consecuencias de las actividades intensivas en capital natural que, como los autores destacan, generan una contradicción importante pues, por un lado, su desarrollo depende fuertemente de la calidad ambiental y a su vez producen daños al medioambiente que hacen peligrar su propia sostenibilidad. Se muestra que el mecanismo de retroalimentación sin acciones ambientales específicas puede afectar significativamente el avance de la región considerada. El tercer trabajo del grupo titulado "Inversiones sectoriales y su relación con la teoría de los *clusters* y el crecimiento económico" tienen por objetivo estimar, mediante el uso de la Matriz Insumo Producto (MIP), los encadenamientos de las ramas productivas de la economía argentina y de otros países seleccionados con el fin de identificar aquellas que más contribuyen al crecimiento económico desde una

perspectiva de *cluster*. El cuarto trabajo, "Un modelo dinámico para la difusión de los rumores con costos de comunicación" presenta un modelo teórico que analiza la propagación de los rumores desde el punto de vista de la teoría de los juegos evolutivos.

La velocidad creciente con que los modelos más abstractos de la teoría económica logran una rápida aplicación a problemas empíricos muestra la necesidad de impulsar el estudio y la investigación en las diferentes áreas de la moderna teoría económica. Los eventos organizados por redes de trabajo tales como JOLATE (Jornadas Latino Americanas y Teoría Económica) y DGS (Dynamics, Games and Science) se convierten en un fuerte estímulo para el desarrollo de la investigación conjunta entre investigadores e instituciones latinoamericanas y europeas en las diferentes áreas de la moderna teoría económica y en particular de la economía matemática.

La organización periódica de eventos de este tipo y la difusión de los avances de los grupos de trabajo contribuirá a enriquecer la interacción entre estudiantes, profesores e investigadores, y permitirá cumplir con una de las funciones sustantivas de la Universidad que consiste en la difusión de las ideas y pensamientos críticos que se dan en el seno del quehacer educativo universitario. Es al servicio de la difusión y desarrollo de la investigación en la moderna teoría económica en sus diferentes aspectos que pretendemos poner nuestra publicación.

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Provision of a merit good by hierarchical government agencies: medications for diabetes in Argentina
Public provision in decentralized systems

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Abstract

Introduction: It is important to evaluate the coverage achieved in the public drugs provision. Aim: to study the provision of a merit good where three levels of government intervene. Materials and methods: We analyze a framework of interaction between government agencies for the provision of certain merit good and a real case of drugs provision for type 2 diabetes mellitus. Results: It can be deduced from the formal framework that, for sequential decisions, the last government level, conditioned by previous decisions, supports the greatest burden of the provision. The case study reveals that the regional level provides the highest percentage of tablets, followed by the local and central levels. Discussion: Drug provision for T2DM is not assured for the share of the population without healthcare insurances, and about 22% of doses were provided voluntarily by the local level, which intervened because levels of provision of other governments proved insufficient.

Keywords

Diabetes mellitus, Decentralization, Public Policies, Resource Allocation

Introduction

The economic theory postulates that, under certain circumstances, the allocation of goods and services through the market, based on individual or collective decisions of economic agents, achieves satisfactory results. Nevertheless, there are certain goods whose provision or financing require State intervention because their consumption is characterized by being non-rival among the agents or by not having limited access (impossibility of excluding the consumption). Among them we can highlight: i) pure public goods and ii) quasi-public goods. On the one hand, the first category considers those goods that manage to satisfy both characteristics. On the other hand, the quasi-public goods satisfy only one characteristic. Moreover, there is another category: merit or preferential goods, which are characterized as private

goods, that is to say, they involve rivalry and exclusivity in consumption, but because they cause important externalities in the social welfare, they must be provided publicly (Oliver, 2011).

Particularly, the goods and services allocated for health care are considered within the latter group, given that the population health status is directly linked to the economic growth and development, as well as employment productivity levels (Ospina, 2011). This impact on social welfare determines that some governments consider essential the State intervention in the decisions of provision, financing and consumption of goods and services carried out in the healthcare sector. Generally, in decentralized contexts, the provision of goods and services for health care is under the responsibility of local government levels, as well as most of their financing (Tobar et al, 2006).

This process is based on efficiency arguments as long as the expenditure is conducted by the level of government that more closely represents the preferences and needs of the inhabitants (Musgrave and Musgrave, 1989). However, one of the problems associated with this scheme consists of the emergence of inequities in the access to health goods and services and the detriment of the jurisdiction with lower revenue-raising capacities (Okorafor and Thomas, 2007). In terms of efficiency, although decentralization allows production to be brought closer to equilibrium levels, by avoiding the waste of resources, it does not ensure that such levels guarantee the technical efficiency as could be observed in the centralized production that, it is assumed, will produce larger quantities at lower unit costs (Moscoso and Modarelli, 2009). The reality demonstrates that the health systems that are being proposed to implement decentralized processes present heterogeneity in the delegation of functions. In particular, different levels of government (local, regional and central) are seen to make decisions above the provision level of goods and services allocated to healthcare, overlapping the actions of the different jurisdictions.

In this context, each level of government must decide such provision based on its budget, the provision costs, the demands, and local needs and the social relevance of the good and/or service in the political agenda. This

behavior can determine different results according to the decision process concerning the strategic interaction of the government levels involved.

In particular, the public provision of pharmacological treatments (Tobar, 2004) for type 2 diabetes mellitus (hereinafter T2DM) tends to be considered a public health policy in those countries where this disease is highly prevalent (Wild et al, 2004). This is due to the high socio-economic burden it imposed on health systems because of the direct costs of the treatment (Brown et al, 2010), indirect costs resulting from the loss of labor productivity (American Diabetes Association, 2008) and the intangible costs associated with the loss of quality of life. In particular, pharmacological treatments necessary for its control accounts for 44% of the direct costs of diabetes (Barceló et al, 2003). For this reason, some governments decide to guarantee public provision, considering this intervention as a preventive policy.

The local levels may present advantages in the provision of health services (Oates, 1972; Oates, 1997), although evidence has been gathered about the negative effects of the decentralization when the services provided have characteristics of public goods (Khaleghian, 2004). At least three reasons that do not guarantee the benefits of decentralization in health have been identified: low technical capacity of local governments, misalignment of the responsibilities in the provision of services for political reasons (unions, national clientelism), and captures by local elites of the government and local budget (Sánchez, 2006).

In the case of the provision of drugs, dissimilar results are verified: while some authors value the benefits derived from the centralized purchases (Barillas, 1997), others reveal economic losses due to waste, thefts, and/or expirations generated by the distribution at the expense of the central level (Tobar, 2008). In cases where the drug procurement is delegated to regional governments, it has been observed that different capacities of management determine differences in the access (Mezones-Holguin et al, 2016).

The use of the Game Theory is justified to the extent that, through a mathematical approach, it allows to study, under certain restrictions and theoretical assumptions, the behavior of agents and the potential results of their behaviors, whether social, economic or political. This conceptual

framework has been applied to the health sector by Westhoff et al. (2012), who describe the importance of using the Game Theory based on two specific theoretical frameworks (The Nash equilibrium and The prisoner's dilemma), so as to improve the understanding of several aspects of public health, such as deciding which services should be provided by two public hospitals serving the same area and which goods should be provided by two natural disaster relief organizations.

In particular, there is a history of using models of the Game Theory to situations in the medications market. By means of a subgame perfect equilibrium, Hollenbeak (1999) solved the case in which a pharmaceutical distributor may suffer the threat of the provision of generic medications and should decide the convenience of passing such drugs to the sale market.

Liang et al (2011) used the Game Theory in an innovative simulation analysis method to study health reform in China considering the results on several agents involved in four different scenarios, which were designed based on the level of drugs coverage and the separation of the functions of prescription and dispensation of them.

Aim

This general aim of this paper is to study the provision of a merit good where three levels of government operate to know if the result achieved is efficient. As regards the specific aims, it is proposed: i) to model the decision of the provision of these types of goods by three levels of governments through the resolution of the formal model for three scenarios: simultaneous, sequential and mixed, ii) to show a case in which the public provision of drugs for the treatment of a pathology involving three levels of government in the city of Bahía Blanca (Argentina) is analyzed.

Material and Methods

As regards the first specific aim, a formal reference framework was developed so as to describe the strategic intricacies of the interaction of three hierarchical

levels of decision. The problem of choosing such levels is analyzed under a framework of the Game Theory analysis. The second aim is to examine the public availability of the main drugs provided for the treatment and control of T2DM: metformin (500 mg) and glibenclamide (5 mg). It is a descriptive and retrospective study that encompasses the period from October 2008 to September 2009. Information on the public availability of the drugs was obtained from the REMEDIAR Program (national level), PRODIABA (provincial level) and the Ministry of Health of the municipality of Bahía Blanca (local level).

The population data was obtained via statistical projections of the 2008 census information, which was compared with the data of the census in 2010 conducted by the National Institute of Statistics and Censuses (INDEC, from the Spanish Instituto Nacional de Estadísticas y Censos).

Results

I) Provision of a merit good at three government levels: formal framework

The problem has been characterized as a multiple decision between levels of provision by means of the three levels already mentioned. Each entity selects, under the restrictions of the case, the allocation of the public money between the expenditure of provision of the merit good and the coverage of other needs.

Our problem focuses, formally speaking, on the evaluation of the different alternatives through a utility function which considers the important variables.

We will suggest the utility function for each entity $i=c,r,l$ [central, regional and local, in a generic way]:

$$U_i\left(d_c^{t_c}, d_r^{t_r}, d_l^{t_l}, R_i\right) = \left(\sum_j d_j^{t_j}\right)^{\alpha_i} \cdot R_i^{(1-\alpha_i)} \qquad \text{(I-1)}$$

where the expressions $d_j^{t_j}$ indicate the amounts of provisions of the good covered by the jth state level in the moment t_j. Thus, we incorporated in the simplest way possible (through a Cobb-Douglas function) the choice between coverage of the merit good and the rest of the budgetary needs for each state tier[5], represented by the variable R_j.

The weighting factor α_i indicates the relative interest that the total provision amount implies for the i-th entity. Such parameter serves as a weighting factor between the relative revenues of the provision of the merit good and the alternative allocations of public expenditure. In the model, it includes all the effects (technical, social and political) that influence the decision of the public agency in charge of making the decision between expenditure on the merit good and the other emoluments.

The choice of each entity from the formulation (I1) will be restricted by a series of conditions. Firstly, each entity is limited by budget constraint of the form:

$$R_i + c_i \cdot d_i^{t_i} \leq G_i \qquad \text{(I-2)}$$

where we consider an available budget of G_i monetary units for the i-th level and a unit cost of a unit of merit good for the ith entity given by the coefficient C_i.

Secondly, the constraints

$$d_i^{t_i} \geq \bar{d}_i \qquad \text{(I-3)}$$

are required.

For each entity i, a prefixed threshold of provision $\bar{d}_i$ is demanded. In

[5] We recall the relative parsimony of the Cobb-Douglas formulation, which represents soft substitution (and constant elasticity) between the variables.

the present paper, we will assume[6] $\forall i \bar{d}_i = 0$.

Additionally, we will adopt the following conditions:

$$0 \leq c_c \leq c_r \leq c_l$$
$$0 \leq \alpha_c \leq \alpha_r \leq \alpha_l$$

These last restrictions guarantee clarity in the presentation of the theoretical results that we will provide later. The first one is based on the effects of scale in the acquisition and distribution of the provision. The second one guarantees that the interest in providing a dose is greater the lower is the tier[7].

We proposed the resolution of the theoretical model for a series of three scenarios.

In the first place, we will present a simultaneous case that serves as an example of the strategic interaction between the entities. In the same way, we will address the scenario in which the entities decide sequentially the levels of provision.

Finally, on a comparative basis, we will discuss the result of a mixed scenario where the local entity decides on the provision of the good in the end, after higher tiers have made their choice simultaneously.

i) Analysis of the simultaneous scenario

Under the framework in which the three levels decide simultaneously[8] their provisions d_i^1 (with $t_c = t_r = t_l = 1$) as previously mentioned, the referential

[6] This assumption constitutes the minimum necessary restriction on the provision (condition of non-negativity). From now on, the model can be generalized with minimum requirements $\bar{d}_i > 0$, without this conceptually affecting the generic results of the analysis.

[7] In other words, the lowest entity values provision the most, since it is the closest to the recipients.

[8] The modeling of the simultaneity of expenditure decisions is linked to a context in which there is no strategic interaction of sequential decisions under which some of the levels could be conditioned by a previous decision of other state tier.

point is the Nash equilibrium of the resulting simultaneous game.

The characterization of the Nash equilibria of the simultaneous game is not simple, since the conditions of non-negativity $\tilde{d}_i^1 \geq 0$ enable the existence of several possible cases (at least different formal expressions for each combination of possibilities). Nevertheless, the basic characteristics of the equilibrium are conceptually similar. Therefore, we will focus on expressing the interior Nash equilibrium (characterized by simultaneous non-negative values of the three provisions d_i^1). The result of each expression $\tilde{d}_i^1$ in the Nash equilibrium is given by:

$$\tilde{d}_i^1 = \frac{(1-\alpha_i)\alpha_j\alpha_k c_i\left(c_j G_k + c_k G_j\right) - c_j c_k G_i \alpha_i\left(\alpha_j + \alpha_k - \alpha_j\alpha_k\right)}{c_i c_j c_k\left[\alpha_i\left(2\alpha_j\alpha_k - \alpha_j - \alpha_k\right) - \alpha_j\alpha_k\right]}$$

where the subscripts j, k describe the variables corresponding to the remaining two levels.

Such an expression certainly does not directly invite economic intuition. Nevertheless, fortunately, the behavior of the individual decision in such a framework responds to what is expected, as can be seen in the following analysis of comparative statistics:

$$\frac{\partial \tilde{d}_i^1}{\partial \alpha_i} > 0 \text{ and } \frac{\partial \tilde{d}_i^1}{\partial \alpha_j} < 0 \text{ (as well as } \frac{\partial \tilde{d}_i^1}{\partial \alpha_k} < 0)$$

[variations in the weightings produce the intuitive effects in the equilibrium response].

$$\frac{\partial \tilde{d}_i^1}{\partial c_i} < 0, \text{ and } \frac{\partial \tilde{d}_i^1}{\partial c_j} \text{ and } \frac{\partial \tilde{d}_i^1}{\partial c_k}$$

are both positive [increases in costs of the provisions for the entity generate a decrease in the coverage of provision, while the opposite occurs when the affected is a rival´s cost].

$$\frac{\partial \tilde{d}_i^1}{\partial G_i} > 0, \text{ and } \frac{\partial \tilde{d}_i^1}{\partial G_j} \text{ and } \frac{\partial \tilde{d}_i^1}{\partial G_k}$$

are both positive [greater availability of resources in an entity produces the expected strategic effect on agents].

Therefore, the modeling of a simultaneous movement of agents allows us to envisage reactions intuitively compatible with the logic of the situation.

We quote the following result:[9]

Theorem 1: For each combination of parameters $(\alpha i, Gi, ci)_{i=n,p,l}$, the simultaneous game has always the Nash equilibrium.

It is important to highlight that, as a summary of the first addressed scenario, the theoretical results of the model satisfy our intuition: in equilibrium, the three hierarchical entities provide levels of provision which are determined according to the values of the parameters $\alpha i, \alpha j, \alpha k, Gi, Gj, Gk, ci, cj, ck$ in an intuitive and natural way.

In all cases of analysis, the general conclusions are similar: the simultaneous interaction leads to a result in which the amounts of the merit good provided by each entity are fixed not only according to the corresponding budget and interest given by the weighting factor itself, but also they are directly influenced by the parameters that characterize the other entities.

ii) Analysis of the sequential scenario

The analysis of the previous scenario sheds light on how knowing the conditions faced by the rival state tiers influences the provision decision. Even so, it is particularly interesting to explore other scenarios that allow us to make inferences about other aspects of possible interaction frameworks: thus, we propose to address the resolution of the scenario in which the three entities (central, regional and local) make the decision of provision in a completely sequential manner.

[9] The result is referred to in the mathematical appendix.

Following the scheme of the preceding paragraphs, we can characterize the subgame perfect Nash equilibrium [SPNE] (Fudenberg and Tirole, 1995) of the commented sequential game. Again, a series of possible ways that can take the sequential equilibrium emerge, by virtue of the combinations of compliance with non-negativity conditions, including 7 possible cases.

We show here the structure of the interior SPNE: the provisions under this equilibrium are given by the following expressions:

$$\tilde{d}_c^1 = \frac{c_r[c_l G_c \alpha_c - c_c G_l(1-\alpha_c)] - c_l c_c G_r(1-\alpha_c)}{c_c c_r c_l}$$

$$\tilde{d}_r^2 = \frac{c_l c_c G_r - (c_l c_r G_c + c_r c_c G_l + c_c c_l G_r)(1-\alpha_r)\alpha_c}{c_c c_r c_l}$$

$$\tilde{d}_l^3 = \frac{c_r c_c G_l - (c_l c_r G_c + c_r c_c G_l + c_c c_l G_r)(1-\alpha_l)\alpha_r \alpha_c}{c_c c_r c_l}$$

We observe that the results of the comparative statics discussed above with respect to the previous scenario are repeated here: the equilibrium endowments respond to increases in the parameters of the intuitively expected form. We add the corresponding existence result:

Theorem 2: In all parameters set $\alpha c, \alpha r, \alpha l, Gc, Gr, Gl, cc, cr, cl$, the sequential game described in this section has a subgame perfect Nash equilibrium. As the most relevant comment of the analysis of the results of the equilibria found in both scenarios, we highlight the fact that the entity with the highest hierarchy obtains the advantage in playing first, if we compare the simultaneous game with the sequential one. In other words, the sequential framework harms the players who define their action later, especially in the last level (local tier). This can be seen in several ways: for example, if we consider the two interior equilibria for each scenario, we will observe the provision values for the central government level:

Under simultaneous decision:

$$\tilde{d}_c^1 = \frac{(1-\alpha_c)\alpha_r\alpha_l c_c(c_r G_l + c_l G_r) - c_r c_l G_c \alpha_c(\alpha_r + \alpha_l - \alpha_r\alpha_l)}{c_c c_r c_l[\alpha_c(2\alpha_r\alpha_l - \alpha_r - \alpha_l) - \alpha_r\alpha_l]}$$

In contrast, the provision of the central government level under the sequential scenario is:

$$\tilde{d}_c^1 = \frac{c_r[c_l G_c \alpha_c - c_c G_l(1-\alpha_c)] - c_l c_c G_r(1-\alpha_c)}{c_c c_r c_l}$$

which implies a smaller provision.

A similar argument can be drawn from the comparison of the corresponding internal equilibria under the symmetric case [$\alpha c{=}\alpha r{=}\alpha l, cc{=}cr{=}cl, Gc{=}Gr{=}Gl$]. In this case we have $\tilde{d}_c^1 = \tilde{d}_r^1 = \tilde{d}_l^1$ under simultaneous decisions, but $\tilde{d}_c^1 < \tilde{d}_r^2 < \tilde{d}_l^3$ when decisions are sequential.

These lines of argument suggest the following result10:

Proposition 3: In all parameters set $\alpha c, \alpha r, \alpha l, Gc, Gr, Gl, cc, cr, cl$, the first player has always incentives to reduce the level of provision, compared to the simultaneous scenario.

[10] We do not present an exhaustive demonstration of the proposition. Note the profusion of cases to be considered: for example, take into account that for a given set of parameter values, a simultaneous interior equilibrium is contrasted with an internal sequential equilibrium in which the national entity provides a smaller but positive provision, while for another set of parameter values, the simultaneous interaction delivers an interior equilibrium while the sequential SPNE yields a null provision. And even for certain values of the variables, a simultaneous internal equilibrium is opposed by a sequential one in which the provincial provision is null, while the national one is positive (but less than the value under simultaneous interaction), and so on.

II) Case study: Provision of drugs to patients with T2DM in the municipality of Bahía Blanca

In Argentina, the health care system is organized through the social welfare sector, the private sector, and the public sector. The latter provides services at the three levels of government (central, regional and local) through hospitals and primary health care centers. Moreover, it is responsible for ensuring medical and health coverage to low-income people, those without health insurance, and/or with geographic limitations to access, and for implementing programs to prevent and/or control chronic noncommunicable diseases such as T2DM.

The public provision of drugs for diabetic patients is carried out through programs that include the financing of glibenclamide and/or metformin, a scheme approved as a treatment for T2DM (Villarreal Ríos et al, 2012; Castro-Ríos et al, 2008). At the central level, the Ministry of Health of the Nation through the REMEDIAR Program offers free access to essential drugs such as those to treat T2DM. At a regional level, the Province of Buenos Aires through the Provincial Program for the Prevention, Diagnosis and Treatment of the Diabetic Patient (PRODIABA) provides pharmacological treatments free of charge to patients who lack health insurance. In turn, the 135 local levels of the Province of Buenos Aires can provide free of charge any good or service in their respective jurisdictions.

In 2005, the health facility census disclosed the perception of the 885 primary health care centers of the Province of Buenos Aires with respect to the adequacy of the number of drugs received for the treatment of T2DM by public programs other than the REMEDIAR Program. This information is presented in Table I.

Table I

At the regional level, the perception of those responsible for the primary health care centers is different according to the drug: in the case of glibenclamide, only 20 % of these primary health care centers claim to receive what is necessary, and for metformin, this percentage is only 15 %.

Those patients with T2DM who lack health insurance and live in the City of Bahía Blanca have access to drugs free of charge provided by the central, regional and local levels. According to information from the Cadaster of the primary health care centers, 82 % of the 45 centers registered in the municipality of Bahía Blanca (Province of Buenos Aires) in 2005 received drugs from different programs.

Table II

Table ll presents the perception of those responsible for the primary health care centers with respect to the adequacy of the amount of drugs for T2DM received by the programs other than the REMEDIAR Program. Unlike the province's total, 40 % and 58 % of the jurisdiction's primary health care centers received adequate amounts of glibenclamide and metformin. However, the amount of primary health care centers that received insufficient amounts of glibenclamide (26 %) and metformin (18 %) is not negligible.

Table III

To evaluate the contribution of the different levels of government in the public provision of drugs for the treatment of T2DM, the treatments provided by the public programs between October 2008 and September 2009 were analyzed. The population arises from estimating potential adult patients with T2DM without health coverage. The population prevalence of diabetes and the frequency of cases of T2DM were applied to the projected population data for 2008 (Instituto Nacional de Estadística y Censos, 2008; Instituto Nacional de Estadística y Censos, 2010) (Conget, 2005; De Sereday, 2004). Under these assumptions, the population with T2DM, potentially user of the public provision of drugs, would be 3274 inhabitants. The population that received treatment was estimated from the availability of tablets and treatments according to drug and prescription doses, which may be: average daily dose (ADD) (Asociación Latinoamericana de Diabetes, 2016), and/or defined daily dose (DDD) (Davis and Granner, 2001)

To estimate the number of patients who received the annual treatment of glibenclamide or metformin, the tablets were converted into treatment quantities according to ADD and DDD and provision of each level (national, regional and local), and they were compared with the population in need of treatment (Table III).

Between 301 and 451 patients would have received their annual metformin treatments free of charge, and between 273 and 410 patients would have received their glibenclamide treatments. The maximum and minimum values arise from considering scenarios of maximum doses (DMD) or minimum doses (maximum DDD). The provision of drugs at the government level reveals that the central level (REMEDIAR Program) provides 13 % of glibenclamide tablets and 6 % of metformin tablets. The regional level provides 87 % of the glibenclamide tablets and more than 70 % of the metformin tablets. Both programs meet the local demand for glibenclamide, but not for metformin.

The percentages of the population receiving the treatments by government level are shown assuming that the lowest doses are provided. In the case of gibenclamide, the regional level provides 87 % of the treatments while the national level provides the remaining 12.93 %. On the other hand, in the case of metformin, the participation of these jurisdictions is lower: the regional level provides 72.06 % of the treatments and the central level 6.43 %. The provision of the remaining treatments is carried out by the local level (Table IV).

Table IV

The local intervention makes it possible to improve access to treatments for approximately 20 % of the potential population demanding these drugs. This provision improves the conditions of equity in access, although is not technically efficient. This is due to the fact that the unit cost of metformin for the local level was $ 0.21 (US $ 0.0530) while the average unit cost paid for the national level (under the REMEDIAR program) was $ 0.11 (US $ 0.0278)). The relationship between unit cost and provision of drugs for type

2 diabetes reveals that, while the central level achieves efficiency criteria, the local level improves the conditions of equity.

Discussion

A formal framework that describes the public provision of goods and private health services in a decentralized institutional context where three levels of government are involved has been presented. It has been determined, through a theoretical assessment, the expectable reaction of the economic agents according to two interactional schemes: a simultaneous game and a sequential game.

It can be observed in both scenarios that each government entity establishes its provision not only based on its own conditionings, but also under the influence of the parameters that characterize the other participants. In this way, it can be deduced that the higher entities, even having the necessary resources and the means to provide the sanitary goods and services at a lower price, can download the burden of public provision on the local level.

This may be due to the fact that, for instance, the hierarchical local level has the necessary incentives to choose an adequate provision since its relative assessment of the total provision of the good at issue is comparatively high with respect to that of other levels. This circumstance is based on the political control exerted by local inhabitants through their role as voters in the political process. At the same time, this hierarchical level is the most concerned with satisfying the sanitary requirements of their population in accordance with the local health demands and the possibility of an electoral punishment.

In particular, this strategic disclaimer on the local entity is greater in the sequential scenario because, as shown above, the capacity to make provisioning decisions first conditions the last agent to take over an even greater part of goods. This result determines important consequences in terms of efficiency and equity. First, an allocation would be efficient if the provision was generated on the level that has the lowest provision costs; under the work assumptions, this would imply that the provision be concentrated in the higher entity. However, due to the inability of the national government

to recognize local needs, it is possible that centralized purchasing in vertical programs be inefficient because it may not strictly adjust to the demands and/or needs.

An alternative path that can alleviate this problem is the design of national programs for the provision and distribution of highly coordinated sanitary goods and services, under which local entities make their orders paying as consideration to their health needs. However, it can be expected that different payment capacities of local entities result in different levels of service provision among local governments, which may not result necessarily equitable.

In our case study it was verified that even with legislations that require the public provision of the central and regional government levels, DMT2 drug provision is not ensured for the uncovered population in a Municipality of the Buenos Aires Province. The access of 22 % of the population that required treatment was guaranteed by a voluntary decision made by the lowest level of government, which intervened after the sequential provision of the higher levels of government proved insufficient to satisfy the local need.

It is important to mention certain limitations of the case study due to the lack of information: i) the doses used do not consider those who consume both drugs, or treat their illness only with diet or insulin; ii) a percentage of the population without health insurance acquires the treatments via out-of-pocket expenses, and iii) it could happen that the treatments demanded in the City of Bahía Blanca are from patients residing in other local levels of the province.

The results show that, in this specific health policy that involves access to medicines for a prevalent chronic pathology, even with laws that require its provision at the central and regional levels, the lowest level of government intervenes, facing higher unit costs than the central level.

The main weakness observed is that even with treatments provided publicly by the three levels, the provisions are insufficient to totally cover the potential demand.

Mathematical Appendix

Proof of Theorem 1: Consider the function of best response for each of the entities i:

$$d_i^1(d_{-i}^1) = \max\left(\frac{\alpha_i G_i}{c_i} - (1-\alpha_i)\cdot\sum_{j\neq i} d_j\,, 0\right)$$

This is a continuous function and its composition $\left(d_i^1(d_{-i}^1)\right)_{i=n,p,l}$ is continuous as well. Each reaction function $d_i^1(\cdot)$ is bounded in the interval $\left[0, \frac{\alpha_i G_i}{c_i}\right]$. Therefore, the fix point theorem of Brouwer can be applied to the composition $\left(d_n^1(d_p^1, d_l^1), d_p^1(d_n^1, d_l^1), d_l^1(d_n^1, d_p^1)\right)$, finding a fix point of that function which constitutes a Nash equilibrium.

Proof of Theorem 2: Consider the function of best response for the last player:

$\tilde{d}_l^3(\bar{d}_n^1, \bar{d}_p^2) = \max\left(\frac{\alpha_l G_l}{c_l} - (1-\alpha_l)\cdot(\bar{d}_n^1 + \bar{d}_p^2), 0\right)$, a continuous function in its arguments.

This response is incorporated into the utility function of the second player and a problem of easy resolution is presented to obtain the reaction function $\tilde{d}_p^2(\bar{d}_n^1)$, which results to be continuous as well in its argument for each possible value.

Finally, the problem of obtaining a dose d_n^1 that maximizes utility is also well-behaved, and can be solved by resorting to the best option $\tilde{d}_n^1$.

Any profile of strategies $\left(\tilde{d}_n^1, \tilde{d}_p^2(\bar{d}_n^1), \tilde{d}_l^3\left(\bar{d}_n^1, \tilde{d}_p^2(\bar{d}_n^1)\right)\right)$ is clearly a Nash equilibrium and it is perfect in subgames.

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Table I: Adequacy in the provision of medications for DMT2 provided by public programs (REMEDIAR Program excluded). Buenos Aires Province, 2005.

Medication for DMT2	Adequacy of the amounts provided				
	Sufficient	Less than sufficient	Little / None	Don't order	Don't Know/ No Answer
Glibenclamide	20 %	15 %	21 %	9 %	35 %
Metformin	15 %	9 %	28 %	13 %	35 %

Source: own elaboration.

Table II: Adaptation of the supply of drugs for DMT2 provided by public programs (REMEDIAR Program excluded). Bahía Blanca, 2005.

Medication for DMT2	Adequacy of the amounts provided				
	Sufficient	Less than sufficient	Little / None	Don't order	Don't Know/No Answer
Glibenclamide	40 %	13 %	13 %	16 %	18 %
Metformin	58 %	9 %	9 %	7 %	18 %

Source: own elaboration.

Table III: Annual free treatments provided by each level of government sorted by the type of dose, Bahía Blanca (Argentina), October 2008 to September 2009.

	Patients under treatment			
	Metformin		Glibenclamide	
	ADA	DDD máx.	ADA	DDD máx.
National level	29	19	53	35
Regional level	325	217	357	238
Local level	97	65	0	0
Total	451	301	410	273
Population with DMT2	3274			
Percentage of population with treatment	13.78 %	9.19 %	12.52 %	8.34 %
Optimistic Hypothesis	26.30 % of the population receives treatment			
Pessimistic Hypothesis	17.53 % of the population receives treatment			

Source: own elaboration.

Table IV: Percentage of patients that received free of charge treatment according to level of government and the ADA (or minimum dose).

	Metformin	**Glibenclamide**
Jurisdiction	ADA	ADA
Central Level	6.43 %	12.93 %
Regional level	72.06 %	87.07 %
Local level	21.51 %	0 %

Source: own elaboration.