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An Analysis of the Impact of Public Infrastructure Spending in Quebec

David Bahan

Alexandre Montelpare

Luc Savard

UNIVERSITÉ DE
SHERBROOKE

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BY

David Bahan[1]
Alexandre Montelpare[2]
Luc Savard[3]

Abstract

The economic literature has been investigating the positive relation between public infrastructure spending and the productivity of the private sector since Munnell (1992). We have thus introduced this relation into the recursive dynamic computable general equilibrium model of Quebec to assess the economic impacts of scaling up infrastructure on the economy. We use we draw our assumptions from Estache et al. (2010) combined with sectoral elasticity parameters from Harchaoui and Tarkhani (2003) based on Canadian estimations. We conduct a comparative analysis between a scenario without positive external effects of infrastructures, and another with positive externalities. The investments are financed by debt. The externalities help attenuate the negative macroeconomic effects associated with scaling up of infrastructure and amplify the positive effects.

Key Words: CGE model, infrastructure, productivity
JEL codes: D58, H54, H63, O47

[1] Economist, Ministère des finances du Québec.

[2] Economist, Ministère des finances du Québec.

[3] Corresponding author : Professor, GREDI, Université de Sherbrooke, 2500 Boulevard Université, Sherbrooke (Québec) - J1K 2R1, Tel: 819 821 8000 # 65169, Fax: 819 821-7934, Email : Luc.savard@usherbrooke.ca.

1. Introduction

For a number of years, economists have pointed out the existence of a positive relation between investments in public infrastructure and the productivity of the private sectors of the economy (Barro, 1991). For example, better hospitals, roads, schools, and ports enable firms to be more efficient thanks to an improvement in their workers' productivity and/or in their capital. In Quebec, a massive plan for infrastructure renewal was implemented by the Quebec government in 2007 (Secrétariat du Conseil du trésor 2007). The collapse of the Concorde boulevard overpass in Laval in September 2006 was the main trigger for the Quebec government to decide to accelerate public infrastructure repairs in the province. In 2007, the Programme québécois d'infrastructures (PQI) was announced. The January 2009 economic statement illustrates higher public infrastructure spending than the trend in the past ten years (see Figure 1). According to the Quebec government, when we include the investments of the federal government in Quebec, of municipalities, and of Hydro-Québec, public investments weighed in at 5.9% of real GDP in 2009 (ministère des Finances, 2009), a peak over the past 25 years.

Insert figure 1 here

For Quebec, these infrastructure expenditures were also justified by an important maintenance deficit in public capital stock. According to the Treasury Board of Canada Secretariat-TBS (2007), public infrastructures in Quebec are ageing and the accumulated maintenance deficit is estimated at $27 billion. The crisis surrounding the Concorde overpass collapse in September 2006, the continued monitoring of the state of the Champlain Bridge and of the Turcot Interchange in Montreal, and the bursting of water pipes in winter are concrete examples of the obsolescence of the public capital stock in the province. Indeed, most infrastructures in Quebec were built between 1960 and 1980.

Large budgets are now required to maintain a quality comparable to that of OECD countries. According to Gagnon et al. (2008) of Statistics Canada, the average age of Quebec infrastructures reached a peak of 18.6 years in 2000, then dropped to 17.2 years in 2007 (see Figure 2). The drop can be attributed to road investments. Quebec nonetheless possesses infrastructures older than the average in Canadian provinces (17.2 years vs. 16.3 years).

Insert figure 2 here

The five-year plan involving $30 billion covering the 2007-2012 period has been increased to $41.8 billion and extended to 2013 (see Figure 3). The objectives of these investments are to curb maintenance deficits and to answer new needs. Roughly 80 percent of the sum is devoted to maintaining assets already in place and the balance will go towards the construction of new infrastructures (SCT, 2007).

Insert Figure 3 here

Most research on the positive relation between infrastructure spending and productivity has been undertaken in a frame of partial equilibrium and with econometric models. Economists also use computable general equilibrium models (CGE) as an analytical tool to inform policy-makers on the economic impacts of policy reforms. In general, in CGE models, public expenditures and investments are not directly linked to productivity of private sector output. These only have an impact only on the purchase of goods and services and employment in the public sector or the construction sector during the implementation stage. Over the past ten or so years, certain authors have begun to introduce the externalities of public expenditures and investments into these models such

as Savard and Adjovi (1998), Adam and Bevan (2006) and Estache et al (2010). The interest in using this methodology to analyse the scaling up of infrastructure lies in the tool's ability to simultaneously capture the external benefits of investments and most of their costs. The objective of this analysis is to examine the impact of increasing infrastructure spending in Quebec. More specifically, the article compares a situation in which infrastructures have no impact on private sector productivity and another in which these infrastructures produce positive external effects. This framework allows us on one hand to illustrate the importance of considering the usefulness of taking into account the externalities and on the other hand it can be used to illustrate the importance of choosing productive investment projects over non productive ones. The analysis is conducted based on the computable general equilibrium model of the Quebec ministry of finance (CGEMQ). The text is divided into five sections. The first presents the theoretical issuees to take into account for the impact analysis when scaling up infrastructure. The second describes the methodological approach implemented. Section three presents the different simulations and analyzes their results, and we close with some concluding remarks.

2. Theoretical stakes

In the following section, we address the economic stakes associated with an infrastructure increase in the economy. A vast body of literature has developed since Aschauer (1989) published his paper on the importance of public infrastructure spending to stimulate economic growth. We can refer to this relation as a positive externality of infrastructure

spending on private productivity.[4] For example, if a lane is added to a congested highway and this lane adds fluidity to traffic, a positive externality is generated through a gain in time for all users, a decrease in transport costs of merchandise, and improved quality of life. And yet, with the exception of the decrease in transport costs, the other benefits have no price determined by markets and it is partially because of these advantages that the additional lane is built.

Another important and controversial question is whether public infrastructure spending will decrease private investment (crowding-out effect) or will have a multiplier effect (complementarity). There are two schools of thought on the question and there is no consensus in empirical studies. The Keynesian approach stipulates that in a situation of underemployment an increase in public expenditures replaces a weak private investment and is legitimate (idea of complementarity). However, Keynesians do not advocate a deficit when the economy is near full employment. The Neoclassical school advances that there is a crowding-out of private investment. The rise in public expenditures, financed by taxation or debt, increases the demand for goods and services, decreases savings, increases interest rates, and thus decreases private investment (Ahmed and Miller, 1999). Moreover, if the infrastructures are financed by debt, part of the available savings can be shifted to the new issuing of government bonds diverts the private investments towards this type of assets. Abdullatif (2006) asserts, for Japan between 1998 and 2006, that productive investments of the Japanese government financed by the issuing of bonds had a positive effect on the private sector. Based on an econometric

[4] An externality is generated based on an action that positively or negatively affects an economic agent other than the one taking the action but that is not into account by any market (Varian, 1998).

model, Ahmed and Miller (1999) suggest that expenditures in a social assistance program reduce private investment for both developed and developing countries. On the other hand, infrastructure expenditures in transport and communication have a positive effect on private investment for their sample of developing countries and a non-significant effect for that of developed countries. They find that the establishment of a country's infrastructure network has diminishing marginal returns after a threshold is reached. The above-mentioned crowding-out theories were formulated at a time when national financial markets did not have the level of global integration they exhibit today. It is legitimate to question whether an increase in public expenditures affects the national interest rate in a context of financial markets. Abdullatif (2006) maintains that public expenditures financed by loans do not affect the national interest rate because of the integration of world financial markets. Recent experiences in Iceland, Ireland and Greece would lead us to think that Abdullatif (2006) claim would not be valid when debt to GDP ratio increase and get out of control. In the Quebec context, we use the findings of Abdullatif (2006) given the modest increases in debt to GDP ratio over the last few years (including the recession) as a working hypothesis[5]. The stylized facts support this hypothesis, as the Quebec investment program of $41.8 billion over five years is being carried out at the same time as a decrease in Canadian interest rates.[6] However, this trend is in contradiction to what is defended by the proponents of the crowding out assumption. It should nevertheless be kept in mind that the situation might be different in a situation of full employment, which is not the case in Quebec and Canada. However, it is possible

[5] It is important to add as will be described below, the working hypothesis will concern our exogenous interest rate but we will capture a crowding out effect given the budget constraints imposed by the CGE modeling framework.

[6] Interest rates have been at historically low levels for the last three years (see www.bankofcanada.ca).

that in the medium or long term, the massive loans of various governments in the world for infrastructures and the stabilization of their financial systems might lead to inflation and an increase in interest rates, thus harming private investment.

Taxation is another funding option for implementing an investment program. Ahmed and Miller (1999) arrive at the conclusion that financing through an increase in taxation is more harmful to private investment than loans. The crowding-out of private investment by public investment can also take place in another way. Indeed, a significant increase in the demand for public investment can monopolize a larger share of real supply and produce two negative impacts on private investment. First, an increase in demand in the short term without an adequate adjustment of supply in the same time horizon will increase prices, thus raising private investment costs. Second, if the government suddenly monopolizes a larger share of real supply, firms involved in public infrastructure projects may be obligated to turn down private contracts in the short term, thus decreasing private investment. These consequences on private investment are possible in the Quebec context. Firstly, the current infrastructure program is one of the largest in the history of the province. Are the involved sectors able to respond to the demand and continue to supply the demand for private investments without a price increase? The Commission de la construction du Québec (CCQ) planned to hire 14,000 new workers over four years[7] to address the substantial increase in public investments. An increase in demand without an adequate adjustment of supply in the short term leads to a price increase. Secondly, in the context of a world economic crisis, the other North American jurisdictions also invest in their infrastructures, adding to the pressure on supply in this sector. The model will

[7] Commission de la construction du Québec -CCQ (2008).

enable us to take into account most of the effects described, which cannot a priori be analyzed in a frame of partial equilibrium. Using a CGE model that takes into account the various costs and externalities of public investments will allow us to see whether there is a crowding-out effect in the Quebec context.

In sum, though there is no consensus, the literature supports the fact that quality infrastructures have significant positive impacts on economic growth. Certain reserves are nevertheless expressed concerning their scope as well as the dynamic of the relation between public investment and private investment. We therefore analyze the establishment of the program with and without a positive relation between public infrastructure expenditures and economic growth.

3. Methodology

3.1 CGE models and infrastructure

Our objective is to use the CGEMQ and adapt it to capture public infrastructure externalities to analyze the impact of the infrastructure investment program, both with and without positive production externalities. The direct shock on the investment demand, externalities, the crowding-out effect, the direct and indirect costs, and the impact on the sectors and households are taken into account in the model. A CGE model offers an analytical framework in which the economy is represented as a complete system of interdependent components. All economic agents, that is, households, firms, government and the external sectors are all related by transactions on the markets and the price system. The model captures the fact that an economic shock has subsequent effects on the entire system, which is not the case in a partial equilibrium framework, while a

CGE model allows consideration of the feedback effects (indirect effects) of this shock. For example, if the government increases its spending in public infrastructure, the CGE model enables us to take into account the direct effect of the expenditures on the economy, such as the increase in the GDP of the sectors involved, but also the fact that this stimulation of the GDP will increase government fiscal revenues and will modify the remuneration of production factors (Decaluwé et al., 2001). The CGE model provides a way to analyze many types of problems, but is primarily used to simulate changes in taxation in a broad sense. Changes to a direct or indirect tax, a tax credit, a customs tariff, or a transfer can be simulated using a CGE model, and their effects on the economy at large, as well as agents and sectors, can be analyzed (Decaluwé et al., 2001).

3.2. The CGE model for Quebec

The CGEMQ uses the "EXTER" model of Decaluwé *et al* (2001) as a starting point. The specificities of the model are its high level of disaggregation, bi-regional structure, recursive dynamic framework, detailed and realistic representation of the fiscal system, partial mobility (stickiness) of capital, and supply of endogenous labour.[8]

The SAM is decomposed into two regions: Quebec and the rest of Canada (ROC). The two regions have the same level of disaggregation, namely 56 productive sectors, 121 categories of goods and services, and 48 categories of personal expenditure on consumption. There are 150 types of households in Quebec and 155 in the ROC (Bahan

[8] For an elaborate empirical and theoretical presentation of the supply of endogenous labour, the partial mobility of capital, the reader can consult Decaluwé et al. (2010).

et al., 2003). The high level of disaggregation poses considerable challenges for numerical resolution.

As in Ballard *et al*. (1985), de Melo et Tarr (1992) and Blonigen *et al*. (1997) we assume an endogenous labour supply is endogenous. The workers decide on a combination between labour and leisure, which enables consideration of the income and substitution effects in the decision-making process. Essentially, the labour supply increases when real wages increase and transfers from government to households diminish, which enables us to take into account the presence of equilibrium unemployment (Decaluwé et al., 2010). Representative households acquire their income from wages, interests, dividends, transfers between households, and net transfers from the government and from abroad. As for expenditures, households pay taxes, save a fixed proportion of their disposable income, and spend the rest of this income on the consumption of goods and services. With regard to consumption, each representative household then distributes its personal expenditures given an incompressible component (basic need) and a share sensitive to price variations. The *firms* receive the largest share of returns to capital paid by branches, after deduction of depreciation of capital. Firms then pay taxes on their revenues, royalties on natural resources to the government, and dividends and interests to other agents. Governments obtain their revenues from income tax, indirect taxes, and royalties on natural resources. Their expenditures are composed of program expenses, transfer payments to other agents, and payments of interest on their debt. Government investment is financed by public savings. All government balances are endogenous in the model and will positively or negatively affect its total savings.

Finally, private investment is endogenous and determined by the level of savings generated by households, firms, the current account balance, and the depreciation of capital. The savings of households is a fixed part of its disposable income. For firms, it is a balance computed after the representative firm pays dividends, interests on its debt, and transfers to other agents and to the rest of the world. For their part, governments save after having paid their purchases of goods and services, transfers to agents, and their debt service. Once the total level of private investment is determined, it is distributed between branches according to an investment decision rule that puts into relation the capital return and its cost. The new capital is added to the initial capital stock or the capital stock from the previous period as described in the dynamic of the following model.

Dynamic of the model

Using a dynamic model implies taking into account the accumulation of capital and labour force, but also technological progress as well as the evolution of the debt (asset) of agents. The evolution of capital stock is modelled using investment demand functions that link the rate of accumulation to the ratio of capital return over its user cost (Equation [1]).

$$\frac{CINV_{k,\text{infc},rg}}{KD_{k,\text{infc},rg}} = AP_{k,\text{infc},rg} \cdot \left[\frac{rs_{k,\text{infc},rg}}{PK_{rg}\left(tin + dep_{k,\text{infc},}\right)} \right]^{betak_{k,\text{infc},rg}} \qquad [1]$$

where *CINV* is the investment decision, *KD* the capital demand, *AP* the constant, *rs* gross returns to capital, *PK* the replacement cost of capital in the region, *tin* the interest rate, and *dep* the depreciation rate. This equation implies that the higher the gross capital

return (*rs*) compared to its cost (*PK (tin+dep)*), the higher the level of investment (*CINV*). This decision is specific to the region (*RG*), the sector (*INFC*), and the type of capital (*K*). The level of investment at time *t* is used in the dynamic loop of the model by means of the equation for the accumulation of capital to establish the capital stock at period *t+1* as specified in the following equation:

$$KD_{t+1} = (1 - DEP) * KD_t + CINV_t \quad [2]$$

where KD_{t+1} is the capital stock of period *t+1* established by the sum of the depreciated capital stock of the preceding period ($(1 - DEP) * KD_t$) and the investment decision at time *t*. Other adjustment mechanisms are also taken into account in the dynamic component of the model, such as the evolution of the total labour force over time, technological progress, household wealth, government debt, and the private debt of firms. Growth in the labour supply is a function of the demographic growth rate established by the Institut de la statistique du Québec. The productivity of capital grows according to the ratio of the capital stock at period *t* over the initial capital stock. This ratio is integrated into a function of capital productivity where it is multiplied by an exogenous growth rate. As for the labour factor, the growth of productivity is established according to the ratio of government expenditures in education at time *t* over expenditures calibrated at the reference period multiplied by an exogenous growth rate.

In the dynamic of the model, the debt of each level of government, in each region, evolves according to public savings. This debt determines the amount of interests to be paid by each government to the various agents at each period. Households' accumulation of wealth is also a function of their savings. This wealth determines the interest received by each household. Moreover, the evolution of private debt among firms is a function of

their financing need minus amortizations, the financing need being the difference between firms' investment and savings.

Changes made to the CGEMQ

The first attempt at modelling production externalities in surveyed CGE models dates back to Melo and Robinson (1990). Intuitively, since it is important to express the gains in productivity stemming from public investments, we must act at the level of the value added function (see Equation [5]). This is where we can influence the productivity of the labour force (LD_j), of capital (KD_j), and of total factor productivity or TFP (A_j):

$$VA_j = A_j \, LD^{\alpha}_j \, KD_j^{(1-\alpha)} \qquad [3]$$

To establish a positive link between the increase in public capital and the productivity of the labour force and of capital, authors generally introduce a multiplier of productivity Ω_j into Equation [3].

$$VA_j = \Omega_j \, A_j \, LD^{\alpha}_j \, KD_j^{(1-\alpha)} \qquad [4]$$

Next, authors use various functions to generate the positive impact of public expenditures on the VA_j function.

For this application, we adopt the approach proposed by Estache et al. (2007) represented by Equation [5]) below:

$$\Omega_j = (ITP/ITPO)^{\xi}_j \qquad [5]$$

where the productivity parameter is a function of the ratio of public investments in simulation (*ITP*) over public investments at the reference period (*ITPO*) and of the elasticity of investments (ξ_j). The equation reflects the relative increase in public capital and the elasticity of productivity of each sector in relation to this capital. The returns on

public investments are constant. There are more sophisticated approaches, such as the function proposed by Savard and Adjovi (1998) with decreasing returns[9]. We have opted for the approach of Estache et al. (2010), as it is linear and reduces convergence problems encountered in a large dynamic CGE model.[10] This assumption will enable comparative analysis when expenditures are neutral (non-productive) and when they are productive. As in Estache et al., (2010) we assume neutrality of our externality with regard to production factors. This implies that the productivity gain for labour and capital is the same. We assign a specific elasticity to each of the sectors (ξ_j) based on Canadian sectoral elasticities estimated by Harchaoui and Tarkhani (2003).

An equation of accumulation of public capital has been added to the model to determine the public capital stocks for each period. In the original version of the CGEMQ, no distinction was made between public and private capital for the accumulation of capital. In this procedure, we have used the same approach as Adam and Bevan (2007). This equation takes into account basic investments, new investments, and the depreciation of capital. A depreciation rate of 3.5% is used. This rate is drawn from an American study covering the period 1961 to 2000 (Kamps, 2004).

The original equation for debt accumulation has been modified, as we finance infrastructure investment by debt. The debt level can thus vary according to the investments made during the period, along with the public deficit in the period. The

[9] Given the limited time frame of our simulations and the lag in major infrastructure projects, this assumption is defendable. However, as we will highlight later, we will not be able to determine an optimal level of infrastructure investment.

[10] In an ideal situation it is the capital stock that would be used, but since the data are not available, we focus on the variation of the flow of public investments. Implicitly, this amounts to assuming that in the reference period, investments maintain the public capital stock, and that the increase in expenditures will increase the stock or the quality of stock; it is therefore this element that interests us. We can also assume that the productivity gains of the stock are already calibrated in the A_j parameter of our production function.

accumulation of a surplus would enable government to reduce the rate of increase of the debt. As modelled, financing through debt has negative macroeconomic effects on government public finances owing to debt service, which increases. In the version with externalities, however, productivity gains contribute to reducing these negative effects of indebtedness. We use a 4% interest rate in our simulations in order to compare scenarios with and without infrastructure returns. It is important to highlight that the preservation or replacement of assets does not generate positive externalities.

2. Simulation and analysis of results

For the purposes of our comparative analysis, we must carry out three simulations. The first is a reference scenario (business as usual-BAU) that consists of solving the model without an exogenous shock but with the increase in growth variables of the dynamic; for the second, we have chosen to simulate a $1 billion shock on infrastructure expenditures over five years without externalities; and for the third, we reproduce the same shock on public expenditures, but assuming that infrastructure investments will generate positive productivity externalities.

The reference year chosen is 2002, and the same shock is simulated from the year 2003 all the way to the year 2007. However, we solve the model over a longer period to analyze the effects at the end of the program. We pursue the resolution up to 2011. This will allow us to evaluate the impact from 2003-2011. The productivity shock simulated will come into effect in 2004, as we assume that the positive productivity effects occur after the construction of infrastructure. As a result, in the first year of investment, it is primarily the economic activity generated by construction that is propagated in the

model. In our comparative analysis, we use the expressions business as usual (reference scenario) for simulation 1, "first scenario" for simulation 2 in which investments do not generate externalities, and "second scenario" for simulation 3 in which we introduce the positive external effects. As previously stated, investments are financed by debt. The scenarios are presented in Table 1.

Insert Table 1 here

Analysis of results

We present the results of our comparative analysis in relation to the BAU simulation. It should be kept in mind that the reference scenario (BAU) does not include the shock on public investments in infrastructures, while this is the case for the other two simulations. We analyze both scenarios to illustrate the forces at work and their impacts on the macroeconomic variables.

Scenario 1 (no externalities)

Following the increase in investments, the expected effects are an increase in real GDP, investment, and prices in addition to deterioration in current account balance. *Ceteris paribus*, an increase in the demand for investment raises overall demand and exerts upward pressure on prices. This price effect will go against the grain when it comes to the expansion of consumption and of disposable income generated by the injection of new capital into the economy. In terms of the current account balance, deterioration is to be expected. The upward pressure on prices will diminish the competitiveness of Quebec firms and therefore decrease exports, and will push Quebec households and producers to purchase more imported goods. The results on key macroeconomic variables for the period 2003 to 2011 are presented in Table 2 below.

Insert Table 2 here

As anticipated, from 2003 to 2007 total investment is strongly stimulated by the shock on public investment (see Table 2). In 2003 the injection of a $1 billion investment in the economy produces an increase in the consumer price index (CPI) around 0.3%. This contributes to decreasing exports and increasing imports. The deterioration of current account reduces the beneficial effects so that the GDP increases by only $233 million in 2003. This expected effect on current account balance reveal concerns related to "Dutch disease." In this context, this implies that an increase in public expenditures without effect on productivity increases the prices of goods and services in Quebec and decreases the competitiveness of Quebec export sectors. Hence, this highlights the importance of ensuring the effectiveness of infrastructure investments to avoid producing such a negative macroeconomic effect on the Quebec economy. Finally, the magnitude of the price increase leaves consumption and disposable income unchanged despite the injection of $1 billion into the economy through borrowing.

Scenario 2

First, although an economy must adjust, maintain, and increase its public capital stock, there exists an optimal target for governments. Otherwise, investments could create price increases that counterbalance the shock on demand. In the current context, the maintenance deficit is estimated at $27 billion, the average age of the province infrastructures being 1.9 years higher (Gagnon et al., 2008) than the Canadian average. New infrastructure project are needed to help the economy face new challenges to remain competitive[11]. The postulate that the province of Quebec still has productivity gains to

[11] The expansion of highway 30, aiming to create a way to bypass the island of Montreal, is an example of an adjustment to unblock the bridges coming into and out of Montreal and to facilitate trade with the rest of

extract from investments in public infrastructure is plausible. Second, in a context of positive returns on public investments and of low interest rates, it is advantageous for a government to use borrowing to finance its projects. Indeed, given the complexity of evaluating public investments in infrastructures, weak interest rates minimize the chances of unprofitability for the governments' projects. On the other hand, as returns diminish and loan costs increase, infrastructure expenditures can become non-productive, which could lead to an unsustainable budget situation for the government.

As elaborated earlier, the positive productivity externality increases production for capital and labour, thereby diminishing marginal costs of firms and, consequently, introducing downward pressure on prices compared to the previous simulation. Key macroeconomic results are presented in Table 3 below.

Insert Table 3 here

With this assumption, we expect a reduction in most negative effects and an improvement in the positive ones. The price increase is limited and even reversed compared to the reference simulation given the productivity effect. This enables firms to produce at lower cost. This increases their competitiveness on external markets and reduces the deterioration of current account balance. Likewise, after the shock (from 2008 onwards), the increase in percentage of exports is much stronger than that of imports, which demonstrates a favourable trend in the long term for current account balance. The GDP growth is higher than in the previous scenario over the entire period. It should be noted that in 2011 the production increase caused by the productivity effect is slightly reduced

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Canada. The complete remodelling of the Turcot interchange and the transformation of route 185 into a four lane highway are other exemples of new infrastructure needed to increase productivity of the sectors in the economy.

(from 0.43 to 0.42%). This can be explained by the drop in value of public capital. The hypothesis of constant returns on public investments does not allow us to determine an optimal level of public investments. It is important to mention that larger investments would likely exhibit lower returns and risk of higher interest rate could both mitigate the positive effects in the medium to long term.

In this scenario, the downwards pressure on price limits several negative effects of the shock and makes possible the maintaining of household consumption level. The current account balance improves compared to the previous scenario owing to the decrease in production costs. In addition, household disposable income slightly increases at the beginning of the period, and gradually increases as the price reduction is felt. We will compare the evolution over time of the consumer price index (CPI), real GDP, and real consumption generated by our two scenarios to get a general view of the effects. The figures below permit us to visualize and understand the impacts and the dynamics of the simulations.

In our first scenario, the increase in investment without productivity gains leads to a price increase of 0.3% and once the investment program is completed, the prices decrease by 0.1% compared to the BAU simulation. In the short term, an increase in investment demand raises overall demand and puts upward pressure on prices. The increase in the capital-labour ratio (downward pressure on prices) is not enough to compensate the upward pressure on investment demand. This effect appears only at the end of the investment program (starting in 2008) with the slight decrease in prices.

In the second scenario, productivity gains add sufficient downward pressure to progressively counter inflation. From 0.3% in 2003, the price level becomes negative

compared to the reference simulation starting in 2006, that is, three years after the beginning of the investments program. At the end of the program, the productivity gains generate a consumer price index lower than the reference simulation by 0.5%.

Insert Figure 4 here

In the first scenario, the shock contributes to increasing GDP by approximately 0.1% or $252 million on average over the course of the program (from 2003 to 2007). Then, from 2008 to 2011, the new infrastructure stock leaves an average residual effect of 0.03% or $78 million on real GDP because of the increase in capital stock in the economy (see Figure 5). For the second scenario, real GDP grows constantly compared to the reference simulation given the productivity gains of the new public capital. Its impact ranges from 0.01% or $478 million of the GDP in 2003 to 0.4% or $766 million in 2007. The increase in production and downward pressure on prices yields a higher real GDP than in the first scenario. Moreover, when investments end, the Quebec economy is more productive, but we see a slight decrease in productivity gains because of depreciation in public capital stock.

Insert Figure 5 here

In terms of real consumption, we observe very slight effects in the first scenario. The upward pressure on prices limits the multiplying effect of public expenditures (see Figure 6). Households do not seem to benefit from these investments if we consider the price effect and the income effect. The evolution of real consumption provides an illustration of how an inflationary policy is harmful for certain agents. In the second scenario, however, the downward pressure on prices makes the infrastructure program beneficial for both households and production. The gains in real consumption last even after the end of the investment program.

Insert Figure 6 here

By way of final comment, the modelling of the hypothesis of positive externalities of public infrastructure spending financed by borrowing shows that it contributes to improving the income of households and the competitiveness of firms.

Conclusion

In 2007, the Quebec government launched the Programme d'infrastructures Québec (PIQ), one of the broadest infrastructure investment programs in the history of the province. The program aimed to nullify a maintenance deficit of $27 billion and to improve the stock of infrastructures in Quebec. In general, the literature on the subject supports that these public infrastructure expenditures contribute positively to the productivity of the private sector albeit not unanimously. In addition, Savard and Adjovi (1998) show that using weak public expenditure externalities in a CGE model can reverse a number of results in an economic impact analysis compared to an analysis in which

these externalities are not taken into account. In this context, we have introduced into the model of the Quebec ministry of finance hypotheses of productivity gains in line with this type of infrastructure investment. We have chosen to use modelling inspired by Estache et al. (2010). The exponent of the relative increase in public capital stock is a parameter of externality elasticity that reflects how each sector reacts to this relative increase. The elasticities are drawn from Harchaoui and Tarkhani (2003), a Canadian sectoral study covering the period 1961 to 2000. We extended on the existing literature by using a dynamic approach as opposed to Estache et al (2010), we use a much richer (endogenous labour supply and capital sticky mobility among other things) and disaggregated model compared to Adam and Beven (2006) and Levy (2007).

We have conducted a comparative analysis of two scenarios. The first consisted in a neutral shock on the demand for public investments financed by loans. An investment that does not take into account the productivity gains stemming from public capital leads to a price increase, deteriorating household income and current account. This partially cancels out the real gains generated by these investments. The results are consistent with the findings of Adam and Bevan (2006) and of Levy (2007): public expenditures that do not improve the productivity of production factors will lead to perverse effects on the internal and external equilibrium of a given economy. This is what is known as "Dutch disease." Non-productive public investments made by the Quebec government could bring this situation about. Price increases could undermine the competitiveness of exporting firms.

We then added the externality modelling drawn from Estache et al. (2010) to the second scenario and observed an improvement in real variables. The results of certain variables are substantially different and indicate that *productive* public investments benefit the entire economy. These results are coherent with those of Savard and Adjovi (1998), Adam and Bevan (2006), and Levy (2007). Indeed, as Savard and Adjovi (1998) show, adding positive production externalities of public investments into the CGEMQ has been sufficient to reverse the results of the first scenario. This observation illustrates the relevance of taking into account the positive externalities of these investments. It also demonstrates that public decision-makers must be prudent in their choices regarding public projects, hence the importance of relying on a rigorous evaluation process for such projects and of refraining from concluding that all projects generate productivity gains. On another issue, as in Adam and Bevan (2006) and Levy (2007), adding production externalities into the CGEMQ decreases the perverse effects of a price increase generated by public expenditures that can be harmful to a small export-driven economy such as Quebec by deteriorating the external balance. This finding further emphasizes the importance of properly evaluating public investment projects.

To sum up, this application produces two interesting contributions. First, the economic literature tends to support a positive relation between public infrastructure and the productivity of private capital. Investments must nevertheless be productive. If they do not affect supply in a positive way, they can generate inflation and reduce the effect of acting as a multiplier of public expenditures. Second, the addition of a modelling of positive externalities of public investments alters the results of a neutral shock on the

economy. The methodological improvements to the CGEMQ have permitted a comparative analysis with and without externalities of these infrastructures to increase understanding of the dynamics associated with this type of economic policy.

Finally, extension will be explored to enhance analytical precision. Among possible improvements we can cite the introduction of the maintenance costs of public capital, the test of various sources of financing, and the use of different elasticities according to infrastructure type.

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