



HAL
open science

The macroeconomic effects of climate policy: A Keynesian point of view

Nicolas Piluso, E. Le Héron

► **To cite this version:**

Nicolas Piluso, E. Le Héron. The macroeconomic effects of climate policy: A Keynesian point of view. Environmental Economics, 2022, 13 (1), pp.16-27. 10.21511/ee.13(1).2022.02 . hal-03777346v2

HAL Id: hal-03777346

<https://hal.science/hal-03777346v2>

Submitted on 3 Jul 2024




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

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



Distributed under a Creative Commons Attribution - NonCommercial - ShareAlike 4.0 International License

“The macroeconomic effects of climate policy: A Keynesian point of view”

AUTHORS	Nicolas Piluso  Edwin Le Heron 
ARTICLE INFO	Nicolas Piluso and Edwin Le Heron (2022). The macroeconomic effects of climate policy: A Keynesian point of view. <i>Environmental Economics</i> , 13(1), 16-27. doi: 10.21511/ee.13(1).2022.02
DOI	http://dx.doi.org/10.21511/ee.13(1).2022.02
RELEASED ON	Wednesday, 14 September 2022
RECEIVED ON	Saturday, 16 July 2022
ACCEPTED ON	Wednesday, 07 September 2022
LICENSE	 This work is licensed under a Creative Commons Attribution 4.0 International License
JOURNAL	"Environmental Economics"
ISSN PRINT	1998-6041
ISSN ONLINE	1998-605X
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”



NUMBER OF REFERENCES

30



NUMBER OF FIGURES

5



NUMBER OF TABLES

1

© The author(s) 2023. This publication is an open access article.



BUSINESS PERSPECTIVES



LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

Received on: 16th of July, 2022

Accepted on: 7th of September, 2022

Published on: 14th of September, 2022

© Nicolas Piluso, Edwin Le Heron,
2022

Nicolas Piluso, Professor, IUT Paul Sabatier, Business and Administration Management, University of Toulouse Paul Sabatier, France. (Corresponding author)

Edwin Le Heron, Professor, Institute for Political Studies, University of de Bordeaux, France.

Nicolas Piluso (France), Edwin Le Heron (France)

THE MACROECONOMIC EFFECTS OF CLIMATE POLICY: A KEYNESIAN POINT OF VIEW

Abstract

The paper analyzes the effects of introducing a corporate carbon tax on GDP and the effectiveness of this macroeconomic policy. The study is based on constructing a simple Keynesian model with flexible prices. It shows that the carbon tax can have a double beneficial effect on the economy in addition to its favorable effect on the environment: i.e., an increase in GDP and employment. The initial values ($y = 100$; $C = 60$; $I = 18$; $G = 16$; $g(A) = 6$) was used to simulate a positive shock of the carbon tax T , increasing from 1.75 to 1.9. The paper considers three different cases depending on the low (Case 1), medium (Case 2), or high (Case 3) sensitivity of the marginal propensity to consume in response to an increase in the prices of goods. In addition, case 4 is considered: stimulus policy associated with climate policy; and case 5 is: policy to increase nominal wages. The results show that the carbon tax can lead to an increase in prices. Although the tax does not excessively negatively affect consumption, it has a positive effect on GDP via the increase in green investments and the induced increase in public spending. Households are, therefore, not necessarily penalized because they benefit from the multiplier effects of the increase in public spending due to the introduction of the ecological tax. Furthermore, stimulus policy is even more effective when combined with an emissions tax.

Keywords

pollution, carbon tax, inflation, fiscal policy, employment, GDP, model

JEL Classification

E12, E62, Q52

INTRODUCTION

In recent years, certain authors have called for an environmental macroeconomic approach that integrates sustainable development and/or climate policies to reduce greenhouse gas emissions (Jackson, 2009, 2011; Victor, 2012). As a result, some studies have begun to include these aspects in macroeconomic and macro-econometric models. The present study follows such an approach by analyzing the short-term effects of a climate policy within a Keynesian macroeconomic model.

According to Peirera et al. (2016), implementing a carbon tax can generate a triple dividend in terms of growth, ecological footprint, and, incidentally, reducing public deficits. The study draws on Cartelier's model (2018) as it considers the fundamental conclusions of Keynes' general theory (and, in certain aspects, his treatise on money).

In macro-econometrics, many models currently assess the short-term effects of climate policies. Generally speaking, there are two groups of models: neo-Keynesian models, which highlight an economy driven by the dynamics of short-term demand (Allard-Prigent et al., 2010; Klein & Simon, 2010), and computable general equilibrium models, which are inspired by a more neo-classical approach (Babiker et al., 2001). Many studies suggest that the impact of climate policies on GDP would be negative (Söderholm, 2007; Scapecchi, 2010).



This is an Open Access article, distributed under the terms of the [Creative Commons Attribution 4.0 International license](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution, and reproduction in any medium, provided the original work is properly cited.

Conflict of interest statement:

Author(s) reported no conflict of interest

The post-Keynesian literature shows the coherent stock-flow model of Naqvi (2015) and Taylor et al. (2016) or the analysis of Fontana and Sawyer (2013). On the other hand, since the carbon tax has recessive effects, Bovari et al. (2018) argue that with a high carbon price trajectory, a redistribution of wealth in favor of wages is necessary, along with the promotion of employment. The same conclusion was found by Jackson and Victor (2019).

In theoretical macroeconomics, several studies introduce an environmental constraint into the IS-LM model, such as those proposed by Heyes (2000), Sim (2006), and Decker and Wohar (2012). In addition, Fagnart and Germain (2014) introduced climate policy as a carbon tax or pollution permits into the AS-AD model (with flexible prices). The introduction of this kind of environmental tax results in a negative supply shock that causes a vertical shift in the supply curve.

Fagnart and Germain (2014) argued that environmental policies have effects on business costs, and, therefore, on prices as well as supply behavior. The present study considers this hypothesis by stipulating the method for determining prices in the goods market while including the Keynesian idea of involuntary unemployment due to insufficient effective demand. Involuntary unemployment exists in many countries today, changing how supply responds to variations in demand: as long as there is involuntary unemployment due to insufficient effective demand, supply will remain elastic in response to demand (Keynes, 1936).

The scientific problem is as follows: even when prices are flexible and the potentially negative impact of inflation on consumption is taken into account, it is not known whether implementing a carbon tax would necessarily worsen unemployment or reduce the effects of macroeconomic policies. Is it theoretically possible that the carbon tax brings a double dividend (economic and ecological)? The study aims to show that, contrary to assertions in the literature as mentioned above, the answer to this question can be positive. As soon as the economy is in a situation of Keynesian involuntary unemployment, the carbon tax can generate a double dividend (reduction of both unemployment and the ecological footprint) and even reinforce the effects of a Keynesian economic policy if prices are flexible. When the economy exhibits Keynesian involuntary unemployment, the carbon tax will likely have an expansionary effect on employment while reducing the carbon footprint. The impact of the carbon tax on the economy will depend on the sensitivity of consumption to inflation.

1. THEORETICAL BASIS

To answer the question raised in this paper (namely investigate the economic and ecological effects of a carbon tax in an economy with Keynesian unemployment and flexible prices), it was chosen to use the model of Cartelier (2018). The advantage of this model is that it brings together the major teachings of Keynes in the General Theory (asymmetry between entrepreneurs and wage earners, effective demand principle) while avoiding the restrictive assumption of price fixity. Consequently, the introduction of a carbon tax in this model makes it possible to consider its potentially inflationary effect.

In this model, the mode of determination of the endogenous variables is sequential. In this model, the money supply is endogenous, and the interest

rate is exogenous, as assumed in the post-Keynesian tradition. The setting of the interest rate by the central bank determines the interest rate. With a given government spending, the equilibrium condition of the goods market allows simultaneously determining household consumption and equilibrium GDP. With a known equilibrium GDP, the levels of employment and prices are determined (using the relation of equality between the marginal productivity of labor and the real wage). Involuntary unemployment is possible because the GDP determined in this way does not necessarily correspond to the full employment level.

The model introduces a carbon tax on the greenhouse gas emissions of firms. The latter must therefore choose between polluting and spending on anti-pollution measures. A firm's maximization pro-

gram is presented that takes account of such a trade-off. The amount of revenue from the tax allows the government to finance its public expenditures. The carbon tax affects firms' profitability, but it also has a double expansionary effect due to anti-pollution spending and additional public spending.

Nevertheless, the carbon tax leads to a double price increase: an increase linked to the tax itself (firms partially pass on the tax to consumer prices) and an increase linked to the expansion of economic activity. For this reason, the study considers the depression of household consumption caused by the effect of inflation on household expenditure. The macroeconomic effect of the carbon tax will depend on the sensitivity of household consumption to inflation and on the multiplier effects of spending, which also tends to increase income.

Once the theoretical model is established, the study presents numerical simulations to analyze the impact on firms of introducing a carbon tax, using the EVviews software to explore different parameters of consumption sensitivity to the effects of inflation.

The present model considers three markets: the market for goods, the labor market, and the monetary market. The goods in question are associated with three functions, corresponding to consumer goods, capital goods, and goods reducing the level of pollution.

The first equation of the model defines the unit of nominal wages:

$$w = \underline{w}. \tag{1}$$

The second equation concerns the equilibrium of the monetary market. In this equation, the demand for money by households is defined as:

$$M^d = -ai + M_0, \tag{2}$$

where M^d is the nominal amount of money demanded, while the monetary supply of the banking system, assumed to be endogenous, is given as $M = M^s$ and is an autonomous component of the demand for money. The interest rate is thus an exogenous element controlled by the central bank, according to the horizontal tradition.

The third equation specifies the investment volume I , which has a decreasing function with respect to the interest rate i :

$$I = -bi + I_0, \tag{3}$$

where I_0 is the autonomous component of investment and b is an elasticity parameter.

The fourth equation concerns the evaluation of the economy's carbon footprint. Since production involves greenhouse gas emissions, an estimate of the polluting intensity of the technology can be given as follows:

$$Z = \delta y - A, \tag{4}$$

where Z represents the public authorities' estimate of the emissions, y is the production volume, and A is the quantity of pollution avoided by reducing emissions. Z is thus a measure of the carbon footprint [δ being the intensity of pollution] on which the ecology tax will be based.

Before deciding on production volume, a company chooses the quantity of polluting emissions to be avoided given the level of the carbon tax T . To avoid a quantity A of greenhouse gas emissions, a company has to buy a quantity of emission-reducing goods according to the function $g(A)$ (with the assumption that $g(A) = A^\gamma$ with $\gamma > 1$). The predicted unit price of the good is denoted as P_A . Pollution abatement efforts are determined by solving the following maximization problem:

$$\begin{aligned} \text{Min } TZ + P_A g(A) &\equiv \text{Min } T(\delta y - A) + \\ &+ P_A g(A), \quad A \geq 0. \end{aligned} \tag{5}$$

The optimal choice of abatement is given by the equilibrium between the marginal cost of abatement $P_A g'(A)$ and the marginal gain of agreeing to mitigate emissions. Thus, the study obtains a function of reducing emissions, which gives the company the optimal volume of abatement A at every level of carbon tax T .

$$A = \left[\frac{T}{P_A \gamma} \right]^{\frac{1}{\gamma-1}}. \tag{6}$$

Equation (6) specifies the consumption volume, assuming that this function depends on the distributed wealth y and households' expected inflation.

$$C = c(\mu)y + c_0, \tag{7}$$

where c is the marginal propensity to consume and c_0 is the exogenous consumption component. The originality of this function is that it incorporates an expected rate of inflation μ that takes place in the current period. The economy's marginal propensity to consume is assumed to be a decreasing function of the expected rate of inflation:¹

$$\frac{\delta c}{\delta \mu} < 0. \tag{8}$$

Indeed, at constant productivity and salary levels, the increase in prices changes the share of added value in favor of profits. A redistribution of wealth takes place in favor of the social group of entrepreneurs, whose marginal propensity to consume is presumed to be weaker. Yet, the economy's propensity to consume is a weighted average of the propensities of the various social groups that make up the economy. Therefore, because of its redistributive effects, inflation tends to decrease the value of the marginal propensity to consume at the macroeconomic scale.

The following equation deals with public finance, assuming that the state budget is balanced. Public spending G is equal to the product of the carbon tax and the intensity of pollution.

$$G = T(\delta y - A). \tag{9}$$

Equation 12 expresses the volume of aggregated production through the equilibrium of the goods market and can be written as:

$$y = C + I + G + g(A). \tag{10}$$

If each term is replaced by its expression, the study obtains:

$$y = c(\mu)y + c_0 - b(\dot{i}) + I_0 + T(\delta y - A) + A^\gamma. \tag{11}$$

The value of aggregated production is therefore given by:

$$y = \frac{c_0 - b(\dot{i}) + I_0 + A^\gamma - TA}{1 - c(\mu) - T\delta}. \tag{12}$$

The obtained results given by equation (12) are further analyzed and discussed.

According to the Keynesian hypothesis of asymmetry between firms and employees, companies decide on the volume of employment according to the chosen production output. It is worth considering a function of a standard Cobb-Douglas aggregate production, in which the production level entirely determines the labor demand of a company. The present level of employment L is given in equation (13):

$$L = \left[\frac{y}{B} \right]^{\frac{1}{\alpha}} = \left\{ \frac{1}{B} \frac{c_0 - b(\dot{i}) + I_0 + A^\gamma - TA}{1 - c(\mu) - T\delta} \right\}^{\frac{1}{\alpha}}, \tag{13}$$

where $y = BL^\alpha$ with B as average labor productivity and $\alpha < 1$.

Moreover, Keynes (1936) accepted the first classic premise that the marginal productivity of the level of employment is equal to the real wage. Since the volume of employment is known, the value of the real wage can be deduced. However, introducing a climate policy slightly modifies this relationship. Therefore, the study needs to reformulate the company's profit maximization program:

$$\text{Max } Py - wL - TZ - p_a g(A), \quad L \geq 0. \tag{14}$$

Profit is calculated as the difference between sales Py (P being the aggregated price index) and production costs (given as the salary cost wL), the environmental tax TZ , and costs to reduce emissions $P_a g(A)$. This program can be rewritten in the following manner by replacing y and Z with their respective expressions:

$$\text{Max } PBL^\alpha - wL - T(\delta BL^\alpha - A) - P_a g(A), \quad L \geq 0. \tag{15}$$

The first-order condition thus gives $\alpha BL^{a-1} (P - \alpha T\delta) = w$, from which the paper can derive the price of goods:

$$P = \frac{wL^{1-\alpha}}{\alpha B} + \alpha T\delta, \tag{16}$$

where w is given by equation (1) and L is given by (13).

1 This effect is quantitatively weak, but it enables establishing a theoretical degrowth relationship between consumption and the price of goods.

Equation (17) can therefore be rewritten as:

$$P = \frac{w \left[\frac{1}{B} \frac{c_0 - b(i) + I_0 + A^\gamma - TA}{1 - c(\mu) - T\delta} \right]}{\alpha B} + \alpha T\delta. \quad (17)$$

Thus, introducing a climate policy has a slight inflationary impact: the general level of prices increases from an amount $\alpha T\delta$ linked to the carbon tax; it also increases because of additional demand $A^\gamma - TA$. The amount of tax is, therefore, partially reflected in the price of goods.

Finally, the level of employment determined in this economy has no *a priori* reason to correspond to full employment of the workforce. As the level of the active population, L^S is given, the level of unemployment U can then be expressed by:

$$U = L^S - L = L^S - \left\{ \frac{1}{B} \frac{c_0 - b(i) + I_0 + A^\gamma - TA}{[1 - c(\mu) - T\delta]} \right\}. \quad (18)$$

The logic of Cartelier’s model is thus as follows: Setting the interest rate and carbon tax (i and T) → determining total investment ($I+A$) → determining output (Y) and consumption (C) in the goods market → determining the level of employment (L) → determining the real wage (w/P) (knowing the marginal productivity of the employment volume) → determining the general price level (P).

Keynesian models with flexible prices are not common in the literature, even when including the family of contemporary SFC models. Nevertheless, Jean Cartelier’s model is relevant to studying a carbon tax’s effects because prices are perfectly flexible and act on effective demand.

The study aims to introduce an element of climate policy into a Keynesian economy characterized by the existence of Keynesian involuntary unemployment.

2. RESULTS AND DISCUSSION

Knowing how the model is built, the paper can present the main analytical results. In a general way, the results reflect the negative conclusions

in the literature about the economic effects of implementing a carbon tax. Does the amount of the carbon tax constitute a negative supply shock? The paper considers equations (12) and (17) to examine this question.

Economic agents predict the inflationary effect of the tax (equation 17) when they determine the aggregated production (equation 12). This inflationary effect, captured by the variable μ , weakens the value of the multiplier since it decreases the purchasing power of salaried households. In other words, the production equilibrium is lowered at an unchanged level of autonomous spending. Nevertheless, the double ‘side effects’ of the carbon tax end up counterbalancing this depressive effect. First, the tax provides revenue for public spending that increases aggregate demand as well as the value of the multiplier (with the component $T\delta$). Second, the demand for anti-pollution goods also increases the aggregate demand. Indeed, the quantity $A^\gamma - TA$ will necessarily have a positive value if, as assumed, γ is greater than 1 (also, $T < 1$). Consequently, it is impossible to maintain, in principle, that the higher the carbon tax rate, the weaker the multiplier effect on economic activity. The tax’s effect on the economy depends not only on the level of the tax but also on the intensity of the pollution of the existing technology (parameter δ , equation 12), on the expected price of emission-reducing goods (parameter P_a , equation 6), and the parameter γ according to formulas for purchasing those goods (equation 6).

Thus, a simple reading of equation (12) shows that the more a business initially pollutes, the more it will have to acquire a large quantity of emission-reducing goods at a given tax level. Moreover, equation (6) shows that the lower the price and the elasticity of purchasing pollution-mitigating goods, the greater the quantity of these goods that have to be involved in the production process.

Contrary to the predictions of the macro-economic models mentioned above, implementing a climate policy without reallocating the tax revenue elsewhere can potentially increase volumes of production and employment once the additional expenses linked to pollution abatement efforts are considered.

Thus, the model shows that a carbon tax can exert an expansionary effect on the economy within the framework of a Keynesian economy.

This study simulates the effect of an increase in the carbon tax on the economy and, therefore, employment. First, the paper considers three different cases, depending on the low, medium, or high sensitivity of the marginal propensity to consume in response to an increase in the price of goods. The initial values of the macroeconomic variables are: $y = 100$; $C = 60$; $I = 18$; $G = 16$; $g(A) = 6$.

These values are used to simulate a positive shock of the carbon tax T , increasing from 1.75 to 1.9, which implies an increase in public spending financed by the increase in revenue.

2.1. Case 1: Low sensitivity of consumption to price increases

For case 1 (Figure 1), GDP grows rather strongly as a result of the increase in the carbon tax. Macroeconomic variables C and G tend to rise. At the same time, there is a decrease in expenditure for reducing emissions $g(A)$ due to the increased price of goods (which also contributes to pollution mitigation). Despite this, GDP will increase due to an increase in the carbon tax.

Hence, a carbon tax is relatively inefficient from an environmental point of view, leading to a decrease in spending to reduce emissions. This result is para-

doxical because the tax increase ultimately reduces private spending to mitigate the pollution. In fact, it appears that the effect of inflation on anti-pollution spending is stronger than the effect of the tax increase. This result is interesting because it suggests that “too much carbon tax is not a good thing.” However, the existence of the tax will indeed incite agents to pollute less and, in this sense, the carbon tax is still beneficial. Moreover, the surplus of public funds generated by the tax can and should be devoted to ‘green’ investments as part of the fight of governments against climate change.

2.2. Case 2: Medium sensitivity of consumption to price increases

GDP rises due to increased public expenditure G , despite constant consumption and decreased spending for reducing emissions (Figure 2).

2.3. Case 3: High sensitivity of consumption to price increases

Consumption decreases, thereby neutralizing the effect of the increase in public spending; GDP remains constant. An even higher sensitivity of consumption to inflation would lead to an evolution of GDP into negative territory (Figure 3).

In all three cases, the tax increase results in inflation and an increase in employment when the GDP rises. Thus, as this model shows, strengthen-

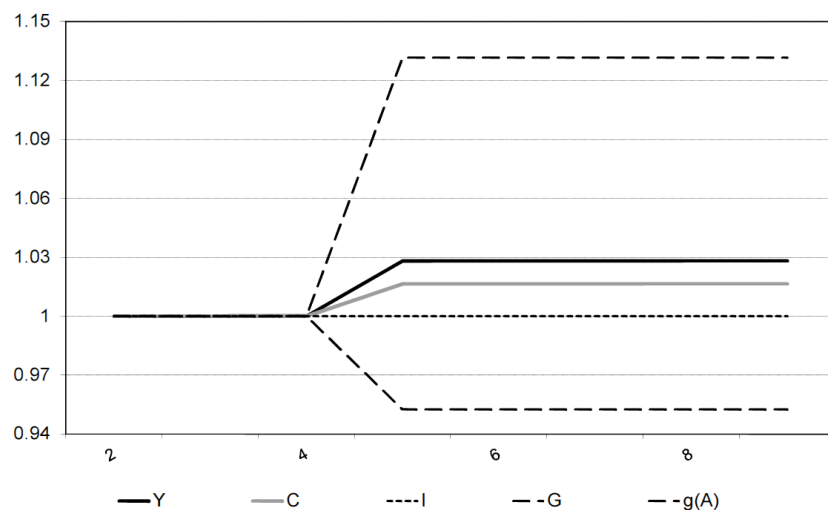


Figure 1. Effect of an increase in the carbon tax on the economy (Case 1)

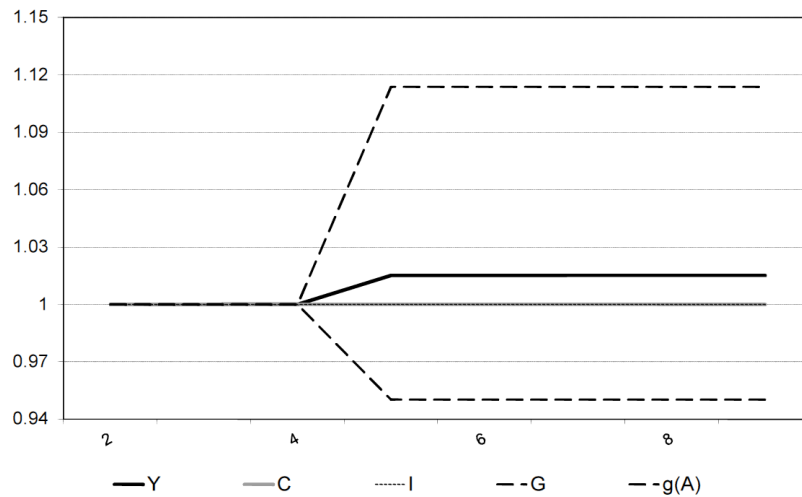


Figure 2. Effect of an increase in the carbon tax on the economy (Case 2)

ing the carbon tax has a generally positive effect on production and employment as it enables better management of the environment via greater public spending. Moreover, this increase in public spending, likely directed to green investments, would largely compensate for the decrease in spending to reduce emissions.

These simulations show that implementing a carbon tax has potentially expansionary effects contrary to what is usually claimed in the literature. The fact is that corporate green investment spending decreases due to inflation can be compensated by the green public spending of the state caused by the introduction of the tax. The carbon tax can therefore generate a double dividend. Why do the

models presented in the literature ignore this possibility? In standard models, the carbon tax only induces an increase in production costs, which leads to a decrease in firms' supply. Demand-side spillover effects are not taken into account because GDP is only determined by the supply side. The Keynesian models cited in the introduction do not consider that the carbon tax can be recycled as an increase in public spending, generating an expansionary effect. Only the fall in investment and consumption is taken into account. This model obtained different results because the level of business supply is determined by aggregate demand. At the same time, the carbon tax increases green public spending, while inflation can have a more or less important effect on consumption and investment.

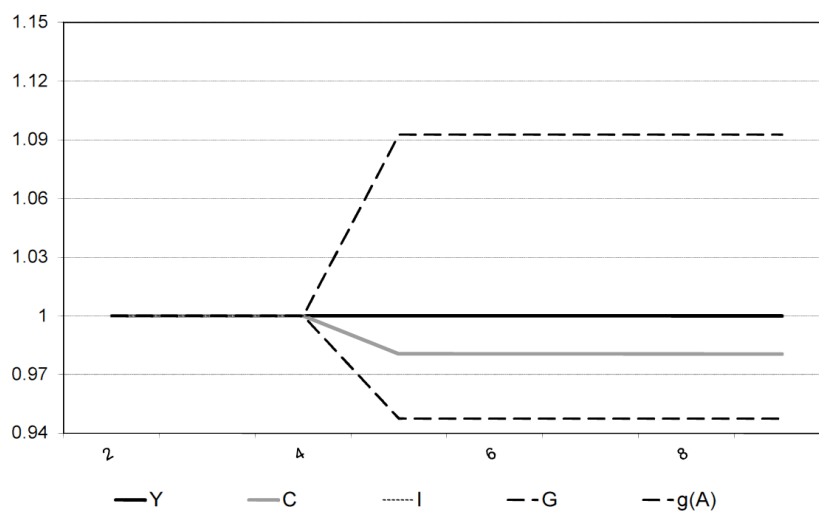


Figure 3. Effect of an increase in the carbon tax on the economy (Case 3)

2.4. Case 4: Stimulus policy is associated with climate policy

In Heyes' model (2000), the ecological constraint renders the fiscal stimulus policy ineffective. Moreover, according to Fagnard and Germain's (2014) model, it is even less effective since climate policy has high ambitions. Thus, the study analyzes the impact of climate policy on the effectiveness of a Keynesian stimulus policy (Figure 4).

Suppose that the state implements a climate policy (in the ways described above) at the same time as a budget deficit financed by issuing treasury bonds. Then the increase in public spending is denoted as ΔG . The equilibrium in the goods market changes, and aggregated production varies in the following manner:

$$\Delta y = \frac{1}{1 - \Delta c(\mu) - T\delta} [\Delta G + \Delta A^\gamma - T\Delta A]. \quad (19)$$

Prices increase correlatively with production:

$$P = \frac{w\Delta L^{1-\alpha}}{\alpha B} + \alpha T\delta. \quad (20)$$

In the absence of a climate policy, the same fiscal stimulus policy would produce the following results:

$$\Delta y = \frac{1}{1 - \Delta c(\mu)} [\Delta G]. \quad (21)$$

The situations described in (19) and (22) can be differentiated by the higher value given to inflation μ in the former (which lessens the multiplying effect) and the appearance of two terms in the latter linked with environmental taxation: $T\delta$ increases the value of the multiplier and $\Delta A^\gamma - T\Delta A$ decreases the effectiveness of stimulus policy. This taxation leads to the appearance a pollution abatement expense A , which clearly decreases because of the increase in the price of goods, but increases the GDP compared to the case with no such expense. If the leading effect of reallocating the tax is higher than the negative effect of inflation, the fiscal stimulus policy is more effective when associated with a carbon tax. In the opposite case, it is less effective.

Comparing the effects of this type of fiscal policy remains somewhat ambiguous at the theoretical level. Hence, the paper performed another simulation to analyze the effects of a stimulus policy assuming a constant rate of the carbon tax (case 4). The study considers the case of low sensitivity of consumption to inflation, with an initial fiscal stimulus of +1.19.

In this case, consumption, government spending, and emission-reduction spending increase simul-

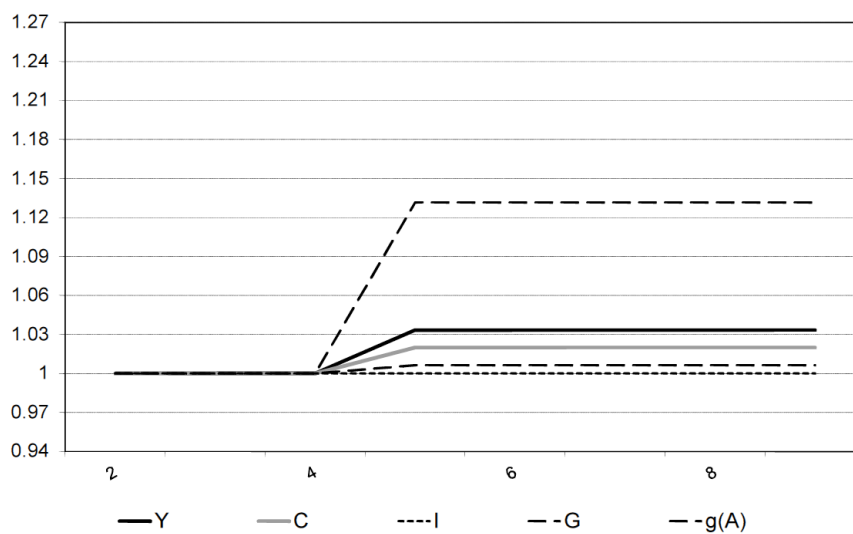


Figure 4. Increased public spending (with the budget deficit) while maintaining the carbon tax (Case 4)

taneously following a fiscal stimulus. The stimulus policy is effective even though it is coupled with a carbon tax. Climate policy reinforces this effectiveness through increased spending on pollution mitigation. Finally, a fiscal stimulus policy also reinforces the effectiveness of the carbon tax from an environmental perspective (increase in anti-pollution spending and an increase in public spending, which would be potentially 'green').

If the state increases its public expenditure while simultaneously increasing environmental taxation to keep the budget balanced, the effect on the GDP is given by:

$$\Delta y = \frac{\Delta G + \Delta A' - \Delta T \Delta A}{1 - \Delta c(\mu) - \Delta T \delta}. \quad (23)$$

Indeed, due to the increase in taxation, a company will increase its efforts to reduce emissions (parameter in equation (6)).

In the absence of a climate policy, and assuming a fixed tax for households affecting their income, a stimulus policy with a balanced budget has the following effect:

$$\Delta y = \frac{1 - c}{1 - \Delta c(\mu)} \Delta G. \quad (24)$$

In the absence of a climate policy (equation (24)), the result concurs with Haavelmo's (1945) findings in which a stimulus policy with a balanced budget is effective but without a multiplying effect (in the case here, the multiplier is close to 1 if the inflation rate is moderate).

In the presence of a climate tax (equation (23)), the results are more complex, including:

- an acceleration of inflation μ in relation to the increase in carbon tax (reduction in the value of the multiplier);
- an increase in the value of the multiplier along with the term $\Delta T \delta$ linked to the increase in the taxation rate: the latter automatically in-

creases the possibilities for public spending (the more the total income increases, the higher the emissions, the greater the tax revenue).

- an increase in magnitude ($\Delta A' - \Delta T \Delta A$) linked to pollution abatement efforts and public investments.²

On the whole, the positive variation of autonomous spending is higher than in a situation without a climate policy. In addition, the value of the multiplier is higher than 1 when there is a carbon tax, whereas it is around 1 without the tax. Consequently, a stimulus policy with a balanced budget is more effective when it is associated with a climate tax.

Compared with the above scenario (case 4), a budget deficit policy is far more effective when coupled with a more aggressive carbon tax (increase in T). The rise in GDP is much greater (+1.06 compared to +1.03),³ despite the decrease in spending to reduce emissions (the effect of inflation on anti-pollution spending is greater than the effect of increasing the carbon tax (case 5, Figure 5)).

2.5. Case 5: Policy to increase nominal wages

In the standard literature, the effectiveness of economic policy depends on the degree of price rigidity. Economic policy to reduce unemployment only works if prices are highly sticky. On the other hand, the carbon tax decreases this policy's effectiveness since it increases firms' production costs and reduces supply. This study provides a more complex analysis. Keynesian macroeconomic policies are effective even if prices are flexible because the production level depends on effective demand. To the extent that the carbon tax can generate an expansionary effect, it can also reinforce the effectiveness of Keynesian policies.

In this Keynesian model, an increase in the nominal wage alone does not affect employment. Indeed, employment determines the real wage and not the inverse. Any increase in the monetary wage only causes an increase in prices in such a way that real

2 In all likelihood, the positive effect of taxation on incentives to reduce emissions is higher than the negative effect of the expected high price of anti-pollution goods.

3 These simulations aim to identify broad trends to support the results from theoretical analysis rather than obtaining precise macroeconomic values in a specific context.

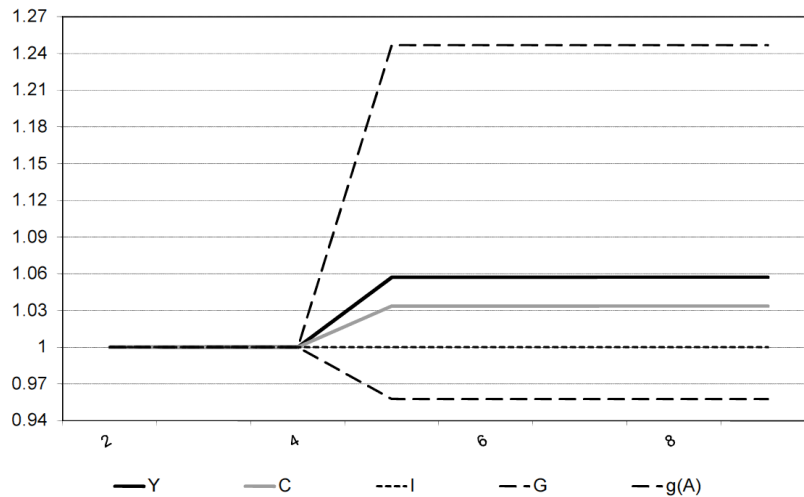


Figure 5. Increase in public spending (with the budget deficit) coupled with an increase in the carbon tax (Case 5)

Table 1. Comparing results of the AS-AD model and the ‘Pure Keynesian’ model

Variable	AS-AD Model by Fagnard and Germain (2014)	Keynesian Model
Climate policy alone	<ul style="list-style-type: none"> Negative supply shock; Positive demand shock; The more ambitious the climate policy and the less rigid the wages, the less expansive the model. 	<ul style="list-style-type: none"> The value of the multiplier is weakened by inflation but increased by the effect on public spending. The supply shock is not necessarily negative; Demand shock positive (anti-pollution spending and/or public spending); The expansive effect is independent of the nominal wage level.
Fiscal policy financed by loans + climate policy	<ul style="list-style-type: none"> The more ambitious the climate policy and the less rigid the wages, the less expansive the model. 	<ul style="list-style-type: none"> Fiscal policy is <i>likely</i> to be more expansionary when coupled with climate policy because of the dual demand shock.
Fiscal policy financed by a carbon tax	<ul style="list-style-type: none"> Not examined. 	<ul style="list-style-type: none"> Fiscal policy is more effective in the presence of a climate policy.
Wage increase policy + climate policy	<ul style="list-style-type: none"> Recessive effect. 	<ul style="list-style-type: none"> Expansive effect is <i>likely</i> due to the dual demand shock.

wages remain unchanged. This price increase does not affect consumption since the wage-profit distribution remains unchanged, as does workers’ real income. Thus, in the suggested model, increasing wages does not cancel the effects of climate policy, whereas in Fagnard and Germain’s (2014) model, it increases unemployment (Table 1).

These results could be supplemented by an analysis of the possible errors in inflation expectations predicted by economic agents, which could amplify or reduce the effects of the tax on effective demand. A more complex model could also be built considering the negative impact of global warming on the economy.

CONCLUSION

Currently, macroeconomists often argue that climate policy entails costs, decreasing Keynesian policies’ effects. The study aims to show that it is theoretically possible to account for situations where implementing a carbon tax can produce a double economic and ecological dividend, along with an expansionary effect.

From the model developed, the paper explores that the carbon tax can have a positive effect on the economy and carbon footprint if the impact of inflation on consumption is low or medium. Moreover,

Keynesian fiscal policies can be more effective when coupled with a climate policy associated with a carbon tax. The study considers 5 different cases: low, medium, and high sensitivity of consumption to price increases (Cases 1-3), stimulus policy associated with climate policy (Case 4), and policy to increase nominal wages (Case 5). Considering the first three cases, the tax increase results in inflation and an increase in employment when the GDP rises. The research results of case 4 are that a budget deficit policy is far more effective when coupled with a more aggressive carbon tax (increase in T). As for case 5, the rise in GDP is much greater (+1.06 compared to +1.03), despite the decrease in spending to reduce emissions (the effect of inflation on anti-pollution spending is greater than the effect of increasing the carbon tax). Today's governments often steer away from implementing a significant climate policy because they fear its economic effects. The study shows that the effects of the carbon tax are not always negative on the economic level as long as the state uses the proceeds of the tax to invest in the ecological transition.

AUTHOR CONTRIBUTIONS

Conceptualization: Nicolas Piluso.

Formal analysis: Nicolas Piluso.

Investigation: Nicolas Piluso.

Methodology: Edwin Le Heron.

Software: Edwin Le Heron.

Supervision: Nicolas Piluso.

Validation: Edwin Le Heron.

Visualization: Edwin Le Heron.

Writing – original draft: Nicolas Piluso.

Writing – review & editing: Nicolas Piluso.

REFERENCES

- Allard-Prigent, C., Audenis, C., Berger, K., Carnot, N., Duchene, S., & Pesin, F. (2010). *Présentation du modèle MESANGE - Modèle Économétrique de Simulation et d'Analyse Générale de l'Économie* (Document de Travail). Ministère de l'économie, des finances et de l'industrie. (In French). Retrieved from <https://docplayer.fr/18127571-Presentation-du-modele-mesange-modele-econometrique-de-simulation-et-d-analyse-generale-de-l-economie.html>
- Babiker, M. H., Reilly, J. M., Mayer, M., Eckaus, R. S., Wing, I. S., & Hyman, R. C. (2001). *The MIT Emissions Prediction and Policy Analysis (EPPA) Model: Revisions, Sensitivities and Comparison of Results* (Report No. 71). MIT Joint Program on the Science and Policy of Global Change. Retrieved from https://globalchange.mit.edu/sites/default/files/MITJP-SPGC_Rpt71.pdf
- Bovari, E., Giraud, G., & Isaac, F. (2018). Coping with Collapse: A Stock-Flow Consistent Monetary Macrodynamics of global warming. *Ecological Economics*, 147, 383-398. <https://doi.org/10.1016/j.ecolecon.2018.01.034>
- Cartelier, J. (1995). *L'Économie de Keynes*. Paris: De Boeck Université. (In French).
- Cartelier, J. (2018). *Money, Markets, Capital: The Case for a Monetary Analysis*. New York: Routledge.
- Cordonnier, L., Van de Velde, F., & Desmarchelier, B. (2010). Croissance et répartition en présence d'investissements environnementaux non désirés. *Développement Durable et Territoires*, 1(3). (In French). <https://doi.org/10.4000/developpementdurable.8454>
- Creel, J., Heyer, E., & Plane, M. (2011). Petit précis de politique budgétaire par tous les temps – Les multiplicateurs budgétaires au cours du cycle. *Revue de l'OFCE*, 116, 61-88. (In French). Retrieved from <https://www.ofce.sciences-po.fr/pdf/revue/2-116.pdf>
- Decker, C., & Wohar, M. (2012). Substituability or Complementarity? Re-visiting Heyes' IS-LM-EE Model. *Ecological Economics*, 74, 3-7. <http://dx.doi.org/10.1016/j.ecolecon.2011.12.010>
- Fagnart, J.-F., & Germain, M. (2014). Macroéconomie du court terme et politique climatique: quelques leçons d'un modèle d'offre et demande globales. *Recherches économiques de Louvain*, 80, 31-60. (In French). Retrieved from <https://www.cairn.info/revue-recherches-economiques-de-louvain-2014-1-page-31.htm>
- Fontana, G., & Sawyer, M. (2013). Postkeynesian and Kaleckian thoughts on ecological macro-

- economics. *European Journal of Economics and Economic Policies: Intervention*, 10(2), 256-267. <https://doi.org/10.4337/ejeep.2013.02.09>
11. Haavelmo, T. (1945). Multiplier effects of a balanced budget. *Econometrica*, 13(4), 311-318. <https://doi.org/10.2307/1906924>
 12. Hardt, L., & O'Neill, D. W. (2017). Ecological Macroeconomic Models: Assessing Current Developments. *Ecological Economics*, 134, 198-211. <https://doi.org/10.1016/j.ecolecon.2016.12.027>
 13. Heyes, A. (2000). A Proposal for the Greening of Textbook Macro: IS-LM-EE. *Ecological Economics*, 32(1), 1-7. [https://doi.org/10.1016/S0921-8009\(99\)00097-X](https://doi.org/10.1016/S0921-8009(99)00097-X)
 14. Jackson, T. (2009). *Prosperity without Growth – Economics for a finite planet*. London and New York: Routledge.
 15. Jackson, T. (2011). Societal transformations for a sustainable economy. *Natural Resources Forum*, 35(3), 155-164. <https://doi.org/10.1111/j.1477-8947.2011.01395.x>
 16. Jackson, T., & Victor, P. (2019). *Low Grow SFC: A stock-flow consistent ecological macroeconomic model for Canada* (CUSP Working Paper No. 16). Guildford: University of Surrey. Retrieved from <https://cusp.ac.uk/themes/aetw/wp16/>
 17. Keynes, J. M. (1936). *The General Theory of Employment, Interest, and Money*. Cambridge University Press.
 18. Klein, G., & Simon, V. (2010). Le modèle MÉSANGE, nouvelle version réestimée en base 2000. *Les Cahiers de la DG Trésor*, 2, 34-42. (In French). Retrieved from <https://www.tresor.economie.gouv.fr/Articles/c8c71bdc-bc87-4430-b593-ea0ba60c1cf/files/85b1504b-4967-4f7d-92b0-ec96b4d920df>
 19. Naqvi, A. (2015). *Modeling Growth, Distribution, and the Environment in a Stock-Flow Consistent Framework* (Policy Paper No. 18). WWWForEurope. Retrieved from <http://hdl.handle.net/10419/125645>
 20. Peirera, A. M., Peirera, R. M., & Rodrigues, P. G. (2016). A New Carbon Tax in Portugal: A Missed Opportunity to Achieve the Triple Dividend? *Energy Policy*, 93, 110-118. <https://doi.org/10.1016/j.enpol.2016.03.002>
 21. Piluso, N. (2007). The role of uncertainty in the unemployment theory of Keynes. *Cahiers d'économie politique – Papers in Political Economy*, 52, 105-114. Retrieved from <https://ideas.repec.org/a/cpo/journal/y2007i52p105-114.html>
 22. Piluso, N. (2011). Chômage involontaire et rationnement du crédit: une relecture de la relation salaire-emploi. *Economie Appliquée*, 64(4), 69-86. (In French). Retrieved from <https://docplayer.fr/695484-Chomage-involontaire-et-rationnement-du-credit-une-relecture-de-la-relation-salaire-emploi.html>
 23. Piluso, N. (2021). Les enseignements des modèles macroéconomiques écologiques des économistes keynésiens. *Economie Appliquée*, 2, 51-81. (In French). <https://dx.doi.org/10.48611/isbn.978-2-406-12814-4.p.0051>
 24. Rezai, A., & Stagl, S. (2016). Ecological macroeconomics: Introduction and review. *Ecological Economics*, 121, 181-185. <https://doi.org/10.1016/j.ecolecon.2015.12.003>
 25. Rezai, A., Foley, D. K., & Taylor, L. (2012). Global warming and economic externalities. *Economic Theory*, 49(2), 329-351. <https://doi.org/10.1007/s00199-010-0592-4>
 26. Scapecchi, P. (2010). L'évaluation des coûts macroéconomiques des politiques de réduction des émissions de GES. *Les cahiers de la Direction Générale du Trésor*, 5. (In French). Retrieved from <http://gesd.free.fr/dgtpe510.pdf>
 27. Sim, N. C. S. (2006). Environmental Keynesian Macroeconomics: Some Further Discussion. *Ecological Economics*, 59(4), 401-405. <https://doi.org/10.1016/j.ecolecon.2005.11.006>
 28. Söderholm, P. (2007). *Modelling the Economic Costs of Climate Policy* (Research Report No. 14). Luleå University of Technology. Retrieved from https://www.researchgate.net/profile/Patrik-Soderholm/publication/281454629_Modelling_the_Economic_Costs_of_Climate_Policy/links/55e89ff108ae21d099c182de/Modelling-the-Economic-Costs-of-Climate-Policy.pdf
 29. Taylor, L., Rezai, A., & Foley, D. (2016). An integrated approach to climate change, income distribution, employment, and economic growth. *Ecological Economics*, 121, 196-205. <https://doi.org/10.1016/j.ecolecon.2015.05.015>
 30. Victor, P. A. (2012). *Managing without Growth. Slower by Design, not Disaster*. Edward Elgar.