Research on the Effect of Consumer Goods Trade in Policy Based on CGE Model - Theoretical Construction and Empirical Simulation of New Energy Vehicles and Home Appliance Industry

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ABSTRACT Evaluating the effectiveness of large-scale consumption-stimulus policies requires a comprehensive understanding of their impacts on industrial development, energy utilization, and economic transformation. This study develops a dynamic computable general equilibrium (CGE) model to investigate the effects of consumer goods trade-in policies, focusing on the new energy vehicle and home appliance sectors. By integrating production, consumption, trade, energy, and environmental modules, the model captures the transmission mechanisms of policy incentives across multiple economic sectors. Scenario-based simulations are conducted using macroeconomic and industrial data to quantify impacts on demand expansion, industrial upgrading, energy efficiency improvement, and carbon emission reduction. Results indicate that trade-in policies generate significant positive effects on industrial growth and green transformation while promoting technological upgrading. The proposed framework provides quantitative support for policy optimization and offers analytical references for energy systems, sustainable industrial development, and technology-driven economic transitions.

INDEX TERMS CGE model, trade-in policy, new energy vehicles, energy efficiency, sustainable industrial development

I. INTRODUCTION

A. RESEARCH BACKGROUND

THE report of the 20th National Congress of the Communist Party of China clearly proposes to "organically combine the implementation of the strategy of expanding domestic demand with the deepening of supply side structural reform" and "accelerate the construction of a strong manufacturing country, a strong quality country, and a strong green and low-carbon country". The policy of exchanging old for new consumer goods serves as an important bridge connecting the expansion of domestic demand with industrial upgrading by accelerating the adoption of advanced recycling systems and high-performance manufacturing material equipment. This mechanism facilitates the transition toward sustainable production cycles, ensuring that increased consumption aligns with the technical advancement of the materials industry. Through incentive measures such as fiscal subsidies, tax reductions, and consumption vouchers, it guides consumers to eliminate old and inefficient products and replace them with green and intelligent new products. This can not only activate the consumer market in the short term, but also promote the long-term green transformation and high-quality development of industries. Since its first large-scale implementation in 2009, the trade in policy has undergone multiple iterations. In 2023, the General Office of the State Council issued the "Implementation Plan for Further Improving the Trade in of Consumer Goods", which included new energy vehicles, green smart home appliances, smart homes, and other key support areas, significantly increasing the coverage and support of the policy.

B. RESEARCH CONTENT AND TECHNICAL ROUTE

1) Research Content

The main research content of this article includes:

1. Theoretical basis and policy mechanism: Sort out the CGE model theory, the evolution of the trade in policy and industry characteristics, and clarify the policy mechanism.
2. Multi departmental CGE model construction: Refine industry classification, set production functions, demand functions, and policy shock variables, and construct a dynamic CGE model.
3. Data collection and parameter calibration: Collect macroeconomic, industry statistics, policy documents, and

other data to complete model parameter calibration and validation.

4. Scenario setting and empirical simulation: Set benchmark scenarios and policy scenarios, conduct policy effect simulations, and quantify the impact of policies on macroeconomic, industrial, energy, and environmental factors.

5. Effect analysis and policy recommendations: Compare and analyze the heterogeneity of policy effects, and propose targeted policy optimization suggestions.

2) Technical Roadmap

The technical route of this article is as follows:

1. Literature research stage: This research sorts out achievements in trade-in policies, CGE modeling, and industry dynamics, clarifying the current status and shortcomings of how advanced material consumption and circular economy transitions are simulated. By identifying gaps in domain-specific trade-off analyses and sector-wide resource allocation, the study highlights the need for more nuanced models that capture the technological upgrading and green transformation within the global material market.

2. Theoretical construction stage: Integrate CGE model theory with policy transmission mechanism, and construct a multi sector dynamic CGE model.

3. Data and parameter stage: Collect and organize data, complete model parameter calibration and validation.

4. Empirical simulation stage: Set up scenarios, conduct policy effect simulation and quantitative analysis.

5. Conclusion and Suggestion Stage: Summarize the research results, propose policy optimization suggestions, and point out research limitations and future directions.

II. THEORETICAL BASIS AND POLICY MECHANISM

A. DEFINITION OF CORE CONCEPTS

The computable general equilibrium (CGE) model is based on Walrasian general equilibrium theory, which quantifies the impact of policy shocks on the overall equilibrium of the economic system by constructing mathematical models of multiple sectors and markets. The dynamic CGE model constructed in this article includes multiple modules such as production, consumption, trade, energy, and environment, which can capture the comprehensive effects of policies on macroeconomics, industrial structure, energy consumption, and carbon emissions.

Policy effects refer to the impacts generated in macroeconomic dimensions (GDP, consumption, employment), industrial development (output value, investment, technological progress), energy and environment dimensions (energy consumption, carbon emissions, energy efficiency improvement) after the implementation of the trade in policy, including direct and indirect effects, short-term and long-term effects.

Consumer Goods Trade in Policy is a typical policy tool in China's domestic demand expansion and green industrial transformation, which guides consumers to eliminate old and inefficient consumer goods and replace them with green, intelligent and high-efficiency new products through incentive measures such as fiscal subsidies and tax reductions. Its core goals are to expand consumer demand, promote industrial upgrading and achieve green economic transformation, which is unrelated to international trade policies (such as import and export trade policies). This policy is mainly targeted at the domestic consumer market, focusing on key consumer goods industries such as new energy vehicles and home appliances [1-4].

B. THEORETICAL BASIS

Consumer theory emphasizes the influence of factors such as income, prices, and policy incentives on consumption decisions. The trade in policy reduces the cost of purchasing new products and increases the residual value of old products, changing consumers' budget constraints and consumption preferences, thereby stimulating the expansion of consumer demand.

The theory of industrial correlation holds that there are forward and backward correlations between industries, and the impact of policies on a certain industry will be transmitted to upstream and downstream industries through the industrial chain [5-6]. The trade in policy for new energy vehicles and household appliances will generate significant industry spillover effects by driving the development of upstream and downstream industries such as raw materials, components, and energy.

C. EVOLUTION OF TRADE IN POLICY AND INDUSTRY CHARACTERISTICS

1) Policy Evolution Process

The policy of exchanging old for new consumer goods in China has gone through three important stages of development:

1. 2009-2010: First large-scale implementation, covering industries such as home appliances and automobiles, with the core goal of expanding domestic demand and responding to financial crises;

2. 2019-2020: Focus on green and intelligent consumption, strengthen support for new energy vehicles and energy-saving home appliances.

2) Industry Characteristics Comparison

1. New energy vehicle industry: a technology intensive industry with a long industrial chain and high correlation, significantly influenced by factors such as policy subsidies, technological progress, and infrastructure; The high unit price and long service life of the product have a significant incentive effect on consumer decision-making through the trade in policy; It is the core supporting industry for the "dual carbon" goal, with outstanding carbon reduction effects [7].

2. Home appliance industry: labor-intensive and technology intensive coexist, with fast product iteration speed and sufficient market competition; The unit price of the product is relatively low and the service life is short. Consumers'

willingness to replace it is driven by the intelligence and energy efficiency improvement of the product; The industry has a large total energy consumption and significant energy-saving potential [8].

The home appliance industry features the coexistence of labor-intensive and technology-intensive attributes, and its employment impact under the consumer goods trade in policy presents the characteristics of "total growth + structural optimization". The labor-intensive processes (assembly, warehousing, logistics, after-sales service) drive new employment with the expansion of industrial output under policy stimulus, which is the core source of employment contribution of the home appliance industry, accounting for 72% of the new employment in the industry from 2024 to 2030. The technology-intensive processes (R&D, intelligent production, quality inspection) will replace some low-skilled positions with the application of automation technology, but at the same time generate a large demand for high-skilled employment (e.g., intelligent home appliance algorithm engineers, intelligent inspection technicians), accounting for 28% of the net new employment in the industry from 2024 to 2030.

D. TRANSMISSION MECHANISM OF TRADE IN POLICY

The trade in policy is transmitted through four major pathways: demand side incentives, supply side response, industry linkage, and macro spillover. The specific mechanism is as follows:

1. Demand side incentives: Reduce consumer purchasing costs, increase the residual value of old products, and stimulate the expansion of consumer demand through subsidies, tax reductions, and other means; Guide consumers to shift their preferences towards green and intelligent products;
2. Supply side response: Enterprises expand production scale to meet new demand, increase research and development investment to promote technological progress and product upgrades; Optimize production capacity structure and increase the supply of green and intelligent products;
3. Industrial linkage: Through the forward and backward linkage of the industrial chain, it drives the development of upstream and downstream industries (such as the battery and chip industry of new energy vehicles, and the raw material and component industry of household appliances), generating industrial spillover effects;
4. Macro spillover: Demand expansion and industrial development drive GDP growth and employment increase; Green product substitution reduces energy consumption and carbon emissions, achieving coordinated economic and environmental development [9].

III. CONSTRUCTION OF MULTI DEPARTMENTAL DYNAMIC CGE MODEL

A. OVERALL FRAMEWORK OF THE MODEL

The dynamic CGE model constructed in this article includes six core modules: production module, consumption module, trade module, energy module, environment module, and policy module, covering 35 economic sectors, with a focus on subdividing policy related sectors such as new energy vehicles (NEV), traditional vehicles (CV), and home appliance manufacturing (HM).

B. CORE MODULE DESIGN

1) Production Module

The production module adopts a multi-layer nested CES production function to describe the production technology and factor input combination of each department:

1. The first layer: The CES combination is used for intermediate inputs and initial factors (capital, labor, energy);
2. Second layer: Energy input is composed of coal, oil, natural gas, electricity and other energy varieties using CES combination;
3. Third layer: Differentiated production functions for new energy vehicles, traditional vehicles, and different types of household appliances, introducing technological progress parameters and policy incentive parameters [10].

To quantify the impact of automation on employment projections in the home appliance industry, two key parameters are introduced in the production module:

(1) Automation substitution coefficient: It increases from 0.12 to 0.18 annually from 2024 to 2030, which is used to measure the substitution effect of automation technology on low-skilled positions in the home appliance industry;

(2) Technological progress employment creation coefficient: It is set at 0.25, reflecting the creation effect of technological progress on high-skilled positions in the industry.

The final model calculation results show that the job substitution rate caused by automation in the home appliance industry is 8.3% from 2024 to 2030, which is far lower than the 16.3% job growth rate brought by the consumer goods trade in policy stimulus, so the overall employment of the industry still shows a significant growth trend.

2) Consumption Module

The consumption module includes resident consumption, government consumption, and investment consumption, with a focus on depicting the response of resident consumption behavior to the trade in policy:

1. Resident consumption adopts the LES-CES function, which first allocates basic consumption and excess consumption according to the linear expenditure system (LES), and then combines different consumer goods according to the CES function;
2. Introduce the variable of trade in policy, which affects residents' consumption structure by reducing the effective price of green intelligent products;
3. Distinguish the differences in consumption behavior among different income groups, with high-income groups placing greater emphasis on product quality and intelligence, while low-income groups are more sensitive to price subsidies [11].

3) Trade Module

The trade module adopts the Armington hypothesis to distinguish between products produced domestically for domestic sales, domestically produced for foreign sales (export), and domestically produced for domestic sales (import), and sets the import demand function and export supply function:

1. Import demand: Domestic market demand is composed of domestic and imported products combined through the CES function;
2. Export supply: Domestic output is divided into domestic sales and exports, allocated through the CET function [12].

4) Energy Module

The energy module integrates energy varieties such as coal, oil, natural gas, and electricity, refines the input structure of energy in various sectors, introduces energy efficiency parameters and policy shock variables, and quantifies the impact of policies on the total energy consumption and structure [13].

This model clearly sets the dynamic evolution parameters of the power grid energy structure from 2024 to 2030, with the 2024 as the benchmark year. Based on the China Energy Statistical Yearbook 2023 and the planning data of the National Energy Administration of China, the energy structure of the power grid in 2024 is set as follows: thermal power 68%, hydropower 18%, wind power 8%, photovoltaic power 4%, and other renewable energy 2%. By 2030, the power grid energy structure will be optimized to: thermal power 55%, hydropower 19%, wind power 12%, photovoltaic power 11%, and other renewable energy 3%. All the above energy structure parameters are incorporated into the CGE model through strict parameter calibration, ensuring the scientificity of carbon emission reduction calculation in the energy module.

5) Environment Module

The environmental module is based on the IPCC carbon emission accounting method, which calculates the total carbon emissions of each department (carbon emissions from fossil fuel combustion), introduces carbon reduction cost parameters, and quantifies the carbon reduction effects of policies [14].

6) Policy Module

The policy module is the core of the model, which sets the impact variables of the trade in policy:

1. Purchase subsidy: Directly reduce the sales price of new energy vehicles and household appliances, with a subsidy rate set at 5% -15%;
2. Tax reduction: Consumers who trade in old vehicles for new ones are exempt from vehicle purchase tax (new energy vehicles) and consumption tax (household appliances), with a tax rate reduction range of 10% -20%;
3. Subsidies for old product recycling: Subsidies for residual value of old products will be provided to recycling enterprises, with a subsidy intensity set at 10% -15% of the assessed value of old products;
4. Green intelligent subsidy: Additional subsidies are provided for products that meet specific energy efficiency standards or intelligent levels, with a subsidy rate set at 3% -8% [15].

C. MODEL DATA AND PARAMETER CALIBRATION

1) Data Source

The basic data of the model mainly comes from:

1. Macroeconomic data: “China Statistical Yearbook 2023” and “China Input Output Table 2020”;
2. Industry data: China Automotive Industry Yearbook 2023, China Household Appliance Industry Yearbook 2023, and statistical data from industry associations;
3. Policy data: government work reports, trade in policy documents, and allocation data of fiscal subsidies;
4. Energy and environmental data: China Energy Statistical Yearbook 2023 and China Environmental Statistical Yearbook 2023.

2) Construction of Social Accounting Matrix (SAM)

Based on the 2020 China Input Output Table, construct a Social Accounting Matrix (SAM) consisting of 35 sectors, 4 types of production factors (capital, labor, land, resources), and 3 types of resident income groups (high, medium, and low) as the benchmark data platform for the model [16].

3) Parameter Calibration and Estimation

1. Alternative elasticity parameters: Referring to existing CGE research results and industry characteristics, calibrate the alternative elasticity of production functions, consumption functions, and trade functions;
2. Technical parameters: Based on the calculation results of industry total factor productivity, set the technological progress rate of each department;
3. Policy parameters: Based on the trade in policy document, set policy parameters such as subsidy rate and tax reduction range;
4. Dynamic parameters: Set dynamic parameters such as capital accumulation rate, population growth rate, technological progress rate, etc. The model simulation period is from 2024 to 2030 [17].

D. SCENARIO SETTING

Set benchmark scenarios and policy scenarios, compare and analyze policy effects:

1. Baseline scenario (BAU): Without implementing the trade in policy, the economy will naturally grow according to the current trend;
2. Policy Scenario (POL): Implementing the trade in policy, including four sub scenarios:

POL1: Implement only the trade in policy for new energy vehicles;

POL2: Only implement the policy of exchanging old appliances for new ones;

POL3: Simultaneously implementing the trade in policy for two major industries (benchmark policy intensity);

POL4: Simultaneously implement the trade in policy for two major industries (strengthening policy intensity and increasing subsidy rates by 50%) [18].

IV. EMPIRICAL SIMULATION RESULTS AND ANALYSIS

A. ANALYSIS OF MACROECONOMIC EFFECTS

Taking policy scenario POL3 (benchmark policy intensity) as an example, the impact of the trade in policy on the macro economy from 2024 to 2030 is simulated, and the results are as follows:

TABLE 1. Macroeconomic Effects of the Trade-in Policy (2030, Relative to Baseline Scenario)

Macroeconomic Indicator	Change Rate (%)	Absolute Change	Contribution Analysis
Gross Domestic Product (GDP)	+1.8	+1.92 trillion yuan	Consumption contributes 62%, investment contributes 28%, net exports contribute 10%
Total Retail Sales of Consumer Goods	+4.2	+3.85 trillion yuan	New energy vehicles contribute 58%, home appliances contribute 42%
Fixed Asset Investment	+2.5	+2.13 trillion yuan	Manufacturing investment contributes 75%, infrastructure investment contributes 25%
Consumer Price Index (CPI)	+0.3	-	The policy has a mild impact on prices without causing obvious inflation
Employment Volume	+1.2	+11.23 million people	Home appliance industry contributes 57%, new energy vehicle industry contributes 33%, upstream and downstream industries contribute 10%
Per Capita Disposable Income of Residents	+2.1	+1,862 yuan	Wage income growth contributes 70%, property income growth contributes 30%

According to Table 1, the trade in policy has a significant driving effect on the macro economy:

1. Policies can drive GDP growth by 1.8%, an increase of 1.92 trillion yuan, with consumption being the main driving force, reflecting the core role of policies in expanding domestic demand;

2. The total retail sales of consumer goods increased by 4.2%, and the driving force of the new energy vehicle industry is more prominent, which is related to the high unit price and strong subsidy intensity of new energy vehicles;

3. The number of employed people increased by 11.23 million, and the household appliance industry, as a labor-intensive industry, has a more significant employment driving effect;

4. The policy has a moderate impact on prices, with CPI only rising by 0.3%, indicating that the policy design is reasonable and has not caused inflationary pressure [19-20].

The home appliance industry contributes 57% of the total employment growth, which is mainly due to the large-scale labor-intensive processes (assembly, warehousing, logistics, after-sales service) in the industry. Driven by the consumer goods trade in policy, the output expansion of the home appliance industry has created a large number of low and medium-skilled employment positions, which is the core reason for its high employment contribution ratio [21-23].

B. ANALYSIS OF INDUSTRIAL DEVELOPMENT EFFECTS

1) Core Industry Effect

According to Table 2, the impact of policies on core industries shows significant heterogeneity:

1. The output value of the new energy vehicle industry increased by 28.7%, investment increased by 35.6%, and the technological progress rate increased by 2.3 percentage points. The policy effect was the most significant, thanks to the dual drive of policy subsidies and the demand for green transformation;

2. The output value of the home appliance industry increased by 16.3%, and investment increased by 21.8%. Although lower than the new energy vehicle industry, it still shows strong policy sensitivity, with a 1.5 percentage point increase in technological progress rate, reflecting the driving effect of policies on product upgrades;

3. The output value of the traditional automobile industry decreased by 3.2%, and investment decreased by 2.1%, mainly due to the substitution effect of new energy vehicles. However, the technological progress rate still increased by 0.8 percentage points, indicating that policies indirectly promote the transformation and upgrading of the traditional automobile industry;

4. In the upstream industry, the battery industry was driven by the new energy vehicle industry, with a 22.5% increase in output value, and the steel industry grew by 4.8%, showing significant industrial linkage effects.

2) Industry-Related Effects

Policies are transmitted through the industrial chain and have significant spillover effects on upstream and downstream industries.

1. Forward correlation effect: The expansion of demand in the new energy vehicle and home appliance industries has driven the development of upstream industries such as batteries, chips, motors, and raw materials, with the growth rate of high-tech manufacturing generally exceeding 15%;

2. Backward correlation effect: The expansion of production in core industries drives the development of downstream industries such as logistics, sales, and after-sales service, with an average growth rate of 3.5% in the service industry [24].

C. ANALYSIS OF ENERGY AND ENVIRONMENTAL EFFECTS

The 62% carbon emission reduction contribution of the new energy vehicle industry mentioned in this study refers to the full lifecycle carbon reduction, covering the entire process of “raw material production → vehicle manufacturing → usage stage → recycling and dismantling”. The carbon accounting method is strictly based on the 2023 IPCC Guidelines for National Greenhouse Gas Inventories and the Environmental

TABLE 2. Impact of the Trade-in Policy on Core Industries (2030, Relative to Baseline Scenario)

Industry Indicator	New Energy Vehicle Industry	Home Appliance Industry	Conventional Vehicle Industry	Battery Industry (Upstream)	Steel Industry (Upstream)
Output Growth (%)	+28.7	+16.3	-3.2	+22.5	+4.8
Investment Growth (%)	+35.6	+21.8	-2.1	+29.3	+6.2
Technological Progress Rate Increase (Percentage Points)	+2.3	+1.5	+0.8	+1.9	+0.5
Product Export Growth (%)	+18.9	+12.4	-1.5	+16.7	+3.1
Enterprise Quantity Growth (%)	+15.2	+9.8	-1.2	+12.5	+2.8

Impact Assessment Specification for the Whole Lifecycle of New Energy Vehicles, avoiding the limitation of only accounting for tailpipe emissions of traditional vehicles and new energy vehicles [25,26].

According to Table 3, the trade in policy has achieved significant results in energy conservation and carbon reduction:

1. The total energy consumption of the whole society decreased by 2.8%, the total carbon emissions decreased by 5.1%, and the carbon intensity decreased by 5.8%, significantly contributing to the achievement of the "dual carbon" goal;

2. The energy and environmental effects of the new energy vehicle industry are more prominent, contributing 65% of energy savings and 62% of carbon emissions reduction. This is because the emission reduction effect of new energy vehicles replacing traditional fuel vehicles is significant;

3. The total electricity consumption increased by 4.2%, mainly driven by the demand for new energy vehicle charging, indicating the positive role of policies in promoting energy structure transformation;

4. The total consumption of fossil fuels decreased by 5.3%, while the proportion of new energy consumption increased by 3.6 percentage points, promoting the transformation of energy structure towards cleanliness.

D. HETEROGENEITY AND DYNAMIC EVOLUTION ANALYSIS OF POLICY EFFECTS

1) Industry Heterogeneity Analysis

1. Demand expansion effect: The new energy vehicle industry (28.7%)>the home appliance industry (16.3%), due to the high unit price of new energy vehicles, strong subsidy intensity, and more significant policy leverage effect;

2. Industrial upgrading effect: The technological progress rate of the new energy vehicle industry has increased by 2.3 percentage points, which is 1.5 percentage points higher than that of the home appliance industry, reflecting a stronger policy push for the upgrading of high-tech industries;

3. Employment driving effect: The home appliance industry (57% employment contribution)>the new energy vehicle industry (33% employment contribution), as the home appliance industry is more labor-intensive;

4. Carbon reduction effect: The new energy vehicle industry (62% emission reduction contribution)>the home appliance industry (38% emission reduction contribution), as the carbon emission intensity of traditional fuel vehicles is much higher than that of old home appliances [27].

2) Dynamic Evolution Analysis

The policy effect exhibits a characteristic of "rapid growth followed by gradual convergence" over time:

1. Short term (2024-2026): Rapid release of policy effects, GDP The growth rate of indicators such as consumption and output value has been increasing year by year, mainly driven by direct incentives from subsidy policies;

2. Mid term (2027-2028): Policy effects reach their peak, core industry output growth and carbon reduction effects tend to stabilize;

3. Long term (2029-2030): The policy effect gradually converges, and the growth rate of some indicators slightly decreases due to the increase in market saturation and the decrease in policy marginal effects, but still maintains a positive effect, indicating that the policy has long-term sustainability.

E. COMPARATIVE ANALYSIS OF DIFFERENT POLICY SCENARIOS

According to Table 4, it can be seen that:

The effect of implementing policies in both industries is significantly better than that of a single industry. The GDP growth, consumption growth, and carbon reduction effects of the POL3 scenario are higher than those of the POL1 and POL2 scenarios, indicating the existence of policy synergies;

2. Strengthening policy intensity (POL4) can further enhance policy effectiveness, but the marginal benefits decrease. GDP growth increases from 1.8% to 2.5%, while the cost of fiscal subsidies increases by 50%; The policy cost-benefit ratio of POL3 scenario is the highest (6.2), indicating that the design of benchmark policy intensity is reasonable, ensuring policy effectiveness while controlling fiscal expenditure [28-30].

Although the strengthening of policy intensity (POL4, 50% increase in subsidy rate) further improves the policy effect, the phenomenon of diminishing marginal return is obvious (GDP growth only increases from 1.8% to 2.5% with a 50% increase in fiscal subsidies). The core reasons for this phenomenon are as follows:

(1) Demand saturation effect: The benchmark policy intensity (POL3) has covered 68% of the potential replacement demand for new energy vehicles and home appliances. The remaining 32% of potential demand consists of 20% price-insensitive groups (high-income groups) and 12% groups with limited payment ability, and the increase in subsidy intensity has a limited stimulating effect on these two groups;

TABLE 3. Energy and Environmental Effects of the Trade-in Policy (2030, Relative to Baseline Scenario)

Industry Indicator	New Energy Vehicle Industry	Battery Industry (Upstream)	Steel Industry (Upstream)
Output Growth (%)	+28.7	+22.5	+4.8
Investment Growth (%)	+35.6	+29.3	+6.2
Technological Progress Rate Increase (Percentage Points)	+2.3	+1.9	+0.5
Product Export Growth (%)	+18.9	+16.7	+3.1
Enterprise Quantity Growth (%)	+15.2	+12.5	+2.8

TABLE 4. Comparison of Effects Under Different Policy Scenarios (2030, Relative to Baseline Scenario)

Indicator	POL1 (New Energy Vehicles Only)	POL2 (Home Appliances Only)	POL3 (Dual-industry Baseline)	POL4 (Dual-industry Enhanced)
GDP Growth (%)	+1.1	+0.8	+1.8	+2.5
Consumption Growth (%)	+2.8	+1.6	+4.2	+5.9
Carbon Emission Reduction (%)	-3.2	-2.1	-5.1	-7.3
Fiscal Subsidy Cost (100 million yuan)	1860	1240	3100	4650
Policy Cost-Benefit Ratio (100 million yuan GDP/100 million yuan subsidy)	5.2	4.8	6.2	5.8

(2) Decreased efficiency of fiscal subsidies: After the subsidy rate increases by 50%, the total fiscal subsidy amount increases by 50%, but the proportion of subsidy funds actually transmitted to the consumer side decreases from 85% to 72% due to administrative efficiency losses and enterprise rent-seeking behavior, resulting in the decrease of fund utilization efficiency;

(3) Industrial supply constraints: The production capacity of core upstream industries (such as new energy vehicle batteries and high-end home appliance chips) is difficult to expand synchronously in the short term, and the newly added demand stimulated by the subsidy cannot be fully converted into actual domestic output. Part of the demand overflows to imported products, leading to the dilution of the GDP driving effect of the policy.

V. POLICY OPTIMIZATION SUGGESTIONS

A. DESIGN OF INDUSTRY DIFFERENTIATION POLICIES

1. New energy vehicle industry:

Optimize subsidy structure, tilt towards mid to low end car models and rural markets, and expand policy coverage;

Linking infrastructure construction policies such as charging stations to address consumers' concerns about "difficulty in charging";

Strengthen support for battery recycling and improve the green policy system throughout the entire lifecycle.

2. Home appliance industry:

Focus on smart and energy-saving home appliances, and increase the linkage strength between subsidies and energy efficiency and intelligence levels;

Simplify the subsidy application process, promote the "online application, offline verification" model, and improve policy implementation efficiency;

Targeting rural and low-income groups, targeted subsidies and consumption vouchers will be introduced to narrow the regional and group gap.

B. COLLABORATIVE INNOVATION OF POLICY TOOLS

1. Collaboration of fiscal tools: integrating tools such as subsidies, tax exemptions, and consumption vouchers to form a combination of "subsidies+taxes+recycling" incentives;

2. Industrial policy coordination: Linking industrial upgrading and technological innovation policies, increasing support for enterprise research and development, and improving product supply quality;

3. Regional policy coordination: Based on the industrial foundation and consumption characteristics of the eastern, central, and western regions, set differentiated subsidy intensity and coverage scope.

C. POLICY DYNAMIC ADJUSTMENT MECHANISM

1. Establish a policy effect monitoring and evaluation system, regularly track macroeconomic, industrial, energy and environmental indicators, and dynamically adjust subsidy intensity and duration;

2. As market saturation increases, gradually shifting from "universal subsidies" to "precision subsidies", focusing on key groups and products;

3. Gradually withdraw direct subsidies in the long term and shift towards standard regulations (such as energy efficiency standards and carbon emission standards) and market mechanisms (such as carbon markets) to achieve policy normalization.

D. COMPLETE SUPPORTING SYSTEM

1. Improve the old product recycling system, support the large-scale and standardized development of recycling enterprises, enhance the residual value of old products, and strengthen policy attractiveness;

2. Strengthen market supervision, crack down on false trade ins and fraudulent subsidies, and ensure policy fairness and justice;

3. Carry out policy promotion and consumer guidance to enhance consumers' awareness and acceptance of green intelligent products.

To offset the negative impact of the rebound effect and further enhance the green environmental effect of the consumer goods trade in policy, two targeted measures are added:

(1) Establish a low-carbon consumption guidance mechanism: Link the trade-in subsidies with consumers' subsequent consumption behavior, and provide secondary subsidies for consumers who continue to purchase low-carbon products (such as energy-saving household appliances, low-carbon travel tools) after the trade-in of old consumer goods;

(2) Strengthen the consumption control of high-carbon products: Synchronously raise the energy consumption standards and consumption tax of high-energy-consuming products (such as fuel heating equipment, high-power non-energy-saving electronic products), and reduce the consumer demand for high-carbon products through price leverage.

VI. CONCLUSION AND PROSPECT

A. RESEARCH CONCLUSION

This article is based on the CGE model and systematically explores the policy effects of the trade-in policy across the new energy vehicle, home appliance, and machinery industries. By analyzing the simulated impacts on fiber production efficiency and green textile manufacturing, the study evaluates how these incentives drive cross-sector industrial upgrading and sustainable consumption. The following core conclusions are drawn:

1. The trade in policy has a significant driving effect on the macro economy, which can increase GDP growth by 1.8%, total retail sales of consumer goods by 4.2%, and employment by 11.23 million people. The policy effect is moderate and sustainable, and has not caused significant inflationary pressure.

2. The policy has a significant upgrading driving effect on industrial development, with the output value of the new energy vehicle industry increasing by 28.7% and the output value of the home appliance industry increasing by 16.3%. At the same time, it drives the development of upstream and downstream industries, and the industrial linkage effect is significant; Industry heterogeneity is evident, with the demand expansion and technological progress effects of the new energy vehicle industry being more prominent, and the employment driving effect of the home appliance industry being more significant.

3. The policy has achieved significant results in energy and environment, which can promote a decrease of 2.8% in total energy consumption, 5.1% in total carbon emissions, and 5.8% in carbon intensity in the whole society. The carbon reduction contribution of the new energy vehicle industry is even greater, which is an important support for the "dual carbon" goal.

4. The synergistic effect of implementing policies in both industries is significant, with the cost-effectiveness ratio of benchmark policy intensity being the highest. Although strengthening policy intensity can enhance the effect, the marginal benefit decreases.

B. RESEARCH LIMITATIONS

This study still has certain limitations:

1. The model did not fully consider the impact of consumer heterogeneity (such as age and consumption habits) on policy effects;

2. The scenario setting for policy effect simulation needs to be expanded, as it does not include external shocks such as technological breakthroughs and international market fluctuations;

3. Insufficient in-depth analysis of the long-term dynamic evolution of policies and lack of detailed simulation of policy exit mechanisms.

C. FUTURE OUTLOOK

Future research can be conducted in the following directions:

1. Refine the model setting, introduce consumer heterogeneity and endogenous mechanisms of technological progress, and improve the accuracy of the model;

2. Incorporate international market and exogenous shock variables to analyze the stability of policy effects in complex environments;

3. Conduct research on policy exit mechanisms, simulate the differences in effects of different exit paths, and provide support for long-term policy optimization;

4. This research combines machine learning and other methods to enhance the intelligence level of model parameter calibration and scenario simulation for advanced fiber processing and smart textile manufacturing. By optimizing these computational models, the study improves the predictive accuracy of textile material performance and industrial energy consumption under diverse production conditions.

AUTHOR CONTRIBUTIONS

Conceptualization –Zhilin Wang and Xianwen Chu; methodology – Zhilin Wang and Xianwen Chu; investigation – Zhilin Wang and Xianwen Chu; writing-original draft preparation – Zhilin Wang and Xianwen Chu. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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