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**Colombia**

**Programa de Profundización de la Reforma Fiscal en Colombia II**

**(CO-L1227)**

**EVALUACIÓN MACRO DE IMPACTO**

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1. **Objetivo**
   1. El objetivo del presente estudio es presentar una propuesta de evaluación de impacto ex post (en 2020) del proyecto CO-L1227 utilizando un modelo dinámico de equilibrio general para la economía colombiana. Esta evaluación ex-post buscará verificar el impacto de las acciones de modernización implementadas por el Gobierno de Colombia en coordinación con el Banco Interamericano de Desarrollo (BID), por medio del programa de políticas (PBL) CO-L1227, el cual está orientado a apoyar los esfuerzos en procura de la estabilidad fiscal de Colombia. La evaluación propuesta busca evaluar el impacto del proyecto sobre el déficit fiscal y sobre la deuda publica neta del gobierno central como efecto de equilibrio general de la masificación de la Factura-Electrónica, la cual busca incrementar la recaudación del IVA a partir de tecnologías más eficientes y efectivas de control tributario.
   2. La evaluación está basada en el modelo de equilibrio general descrito en detalle en el anexo de este documento. El modelo representa una economía pequeña y abierta dentro del marco de un modelo de equilibrio general dinámico y estocástico. El modelo ha sido construido con el propósito de servir como herramienta de simulación del impacto económico, en el corto y mediano plazo, de decisiones alternativas de política fiscal. Las ecuaciones del modelo se derivan de las decisiones de optimización intertemporal de las familias y las firmas sujetas a restricciones tecnológicas, presupuestales e institucionales. Las decisiones de los agentes son “forward looking” y la dinámica de la economía se enmarca en el modelo neoclásico de crecimiento, el cual gobierna el comportamiento de la economía en el largo plazo.

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| **Supuesto:** A partir de la masificación de la Factura Electrónica (F-e) para todos los contribuyentes del Impuesto al Valor Agregado (IVA), se genera un incremento de los ingresos tributarios de Colombia. Esto sucede dado que se establece la obligación de reportar todas las compras y contrataciones de servicios de forma electrónica, al momento en que la transacción comercial ocurra, eliminando los errores cometidos intencional o involuntariamente en la emisión de facturas, así como las solicitudes indebidas de créditos fiscales. Con esto, la F-e permitirá a la Dirección de Impuestos y Aduanas Nacionales de Colombia (DIAN) realizar las retenciones de impuestos de forma oportuna, así como contar con toda la información referente al consumo de bienes y servicios del país en tiempo real, para fines de control tributario. |

1. **Contexto y Antecedentes para la Evaluación**
2. **Contexto Macroeconómico y Fiscal.**
   1. **Macroeconómico.** Entre 2014 y 2016, la economía colombiana se deterioró por la caída del precio internacional del petróleo. El Producto Interno Bruto (PIB) entró en una senda de desaceleración del crecimiento, pasando de 4,4% anual en 2014 a 2% en 2016. A su vez, el déficit de cuenta corriente aumentó a un promedio de 5,3% del PIB entre 2014 y 2016, comparado con un promedio de 3,1% del PIB en el periodo 2010‑2013. También, el déficit fiscal del gobierno central se amplió hasta 4% del PIB en 2016 frente a 2,4% en 2013. Por último, por efecto del fenómeno de El Niño y la depreciación del tipo de cambio, la tasa de inflación salió del rango meta (2%-4% anual) en 2015, llegando a 5,7% anual en 2016.
   2. Un manejo prudente de políticas económicas permitió un suave aterrizaje de la economía ante el choque externo y un ajuste gradual de las cuentas externas y públicas. De esta manera, el tipo de cambio actuó como estabilizador automático ante la caída del precio del petróleo, depreciándose un 56% entre 2013 y 2016. La depreciación cambiaria permitió una disminución del nivel de importaciones y aumento de las exportaciones no tradicionales. A su vez, ante la reducción de los ingresos petroleros del Gobierno Nacional Central (GNC), equivalentes a 3,2% del PIB en 2013, el gobierno utilizó una combinación de recorte del gasto público[[1]](#footnote-1) y aumento del déficit para reducir el impacto del ajuste sobre el sector real de la economía. Por otro lado, el Banco de la República realizó una política monetaria restrictiva, subiendo en más de 400 puntos básicos la tasa de referencia, conteniendo la inflación y llevándola a julio de 2017 a 3,4% anual.
   3. **Fiscal.** El Ministerio de Hacienda y Crédito Público (MHCP) proyecta que en 2018 se inicie el fortalecimiento en las finanzas públicas, luego del deterioro asociado al choque externo. Se estima que el déficit del Sector Publico No Financiero (SPNF) pasará de 3,2% del PIB en 2017 a 2,7% del PIB en 2018, mientras el déficit del GNC se reducirá de 3,6% a 3,1% del PIB, entre 2017 y 2018.
   4. La senda de deuda neta como proporción del PIB mantuvo una tendencia creciente desde 2013, alcanzando 33,6% para el SPNF y 43,6% para el GNC, en 2017. La deuda interna neta del GNC registró un nivel de 28,9% del PIB, mientras la externa alcanzó 14,7% del PIB, en dicho año. Como lo explica el MHCP en el Marco Fiscal de Mediano Plazo (MFMP), gran parte del incremento de la deuda del GNC se dio entre 2014 y 2015 como resultado de la depreciación de la tasa de cambio. Para 2018, se espera que la deuda del GNC alcance 43,6% del PIB e inicie una trayectoria descendente en el mediano plazo, consistente con la reducción del déficit fiscal. Las necesidades de financiamiento para 2018 alcanzarán $72 millones de millones de pesos (7,4% del PIB), de los cuales $29,7 millones de millones (3,1% del PIB) corresponden al déficit del GNC y $16,6 millones de millones (1,7% del PIB) a amortizaciones
   5. **Ingresos.** A nivel del Gobierno Central el recaudo tributario en Colombia es bajo (13,6% del PIB) comparado con el promedio de América Latina (15,8% del PIB) y de América del Sur (17,6% del PIB)[[2]](#footnote-2). La recaudación subnacional también es escasa en Colombia. En la actualidad, los departamentos y municipios recaudan aproximadamente 3,1% del PIB, nivel de recaudo muy por debajo de Brasil y menor a Argentina, países con un nivel de descentralización similar al de Colombia, los cuales recaudan 9,8% y 5,9% del PIB, respectivamente[[3]](#footnote-3).
3. **La Factura Electrónica (F-e) en Colombia**
   1. A partir del primero de enero de 2018, todas las empresas del país estarán obligadas a implementar la facturación electrónica como única forma de su registro contable de transacciones. Por ello, para dar cumplimiento al Decreto 2242 de la DIAN, la entidad puso en marcha el proceso de masificación del nuevo modelo, desechando la antigua factura física. Con el nuevo modelo de facturación todas las empresas deberán facturar por este medio, por lo que las empresas deben iniciar la adaptación de la nueva tecnología y capacitación de personal para dar cumplimiento al Decreto.
   2. **¿Qué es la F-e?** La factura electrónica, al igual que la física, es un documento que soporta transacciones de venta de bienes y/o servicios y que debe cumplir con las características y condiciones de expedición, recibo, rechazo y conservación. La expedición de la factura electrónica comprende la generación por el obligado a facturar y su entrega al adquirente.
   3. **¿Cuáles son sus beneficios?** Hay múltiples beneficios para las empresas que implementen la factura electrónica, dentro de los que están:
   4. Tiempos de entrega de una factura pasan de días a minutos.
   5. Mejora en la calidad de datos, se controlan documentos electrónicos.
   6. Incremento exponencial en el proceso de aceptación y rechazo de la factura, mejorando el tiempo de contabilización de la factura de hasta tres días.
   7. Impacto positivo en el flujo de caja por la mejora en el tiempo de contabilización.
   8. Reducción en costos asociados con facturación de hasta 85 %.
   9. **¿Quiénes están llamados a implementar Factura Electrónica?**
4. Las personas naturales o jurídicas que tienen la obligación de facturar y sean seleccionadas por la DIAN para expedir factura electrónica (obligados)
5. Las personas naturales o jurídicas que tienen la obligación de facturar y opten por expedir factura electrónica (voluntarios)
6. Las personas que no siendo obligadas a facturar de acuerdo con el Estatuto Tributario y/o decretos reglamentarios, opten por expedir factura electrónica. (voluntarios)
   1. **¿Qué pasos debo seguir para implementar la Factura Electrónica?**
7. Proceso Fiscal: Surtir el procedimiento de habilitación en la DIAN. Las resoluciones de la DIAN que fijen los seleccionados obligados a facturar electrónicamente entrarán en vigor en un plazo no inferior seis meses.
8. Proceso Técnico: Llevar a cabo las actividades que se estimen convenientes para diseñar, construir o adquirir la solución tecnológica para hacer factura electrónica ya sea directamente (medios propios) o a través de un Proveedor Tecnológico como Carvajal Tecnología y Servicios.
   1. **Datos Complementares**
9. La Factura Electrónica será obligatoria en Colombia.
10. Quien implemente Factura Electrónica debe hacerlo con el 100 % de sus facturas.
11. Quien inicie el proceso de Factura Electrónica no podrá expedir, si fuere el caso, la factura electrónica a que se refiere el Decreto 1929 2007, ni la factura por computador prevista en el artículo 13 del 1165 de 1996, ni la factura por talonario.
12. A la DIAN se le entrega un ejemplar exacto de las Facturas/Notas en un tiempo de 48 horas.
13. El Decreto 1929 está vigente hasta el 1 enero 2018 para quienes surtieron procedimiento DIAN antes del 24 de noviembre de 2015
14. La factura electrónica podrá ser Titulo Valor una vez se expida el Decreto de circulación de las facturas electrónicas que reglamenta la ley 1231 de 2008.
    1. **Otros beneficios generados por la F-e.** La tributación es uno de los deberes de todas las empresas y como es de esperarse, uno de los más grandes beneficiarios de la implementación de la factura electrónica es la DIAN, ya que la F-e dificulta las oportunidades para la evasión fiscal de los contribuyentes respecto al uso de las facturas en papel. Asimismo, la F-e proporciona información actualizada de las retenciones de los contribuyentes, permitiendo a la DIAN incursionar en análisis de riesgo para ser más estratégica y efectiva con las empresas que deben de pasar por una auditoría fiscal. La F-e también proporciona beneficios para las empresas, al tener menos trámites con la DIAN. Una empresa que mantiene sus transacciones transparentes y tributa, puede dedicarse a ejecutar su rol de negocio y no tener carga administrativa adicional con la DIAN. Es decir que la DIAN se dedica a su trabajo (la recaudación) mientras las empresas se dedican al suyo (vender).
    2. Las facturas en papel limitan la capacidad y efectividad de las autoridades fiscalizadoras para combatir el fraude y la evasión. La facturación electrónica facilita la fiscalización y control, permitiendo analizar y cruzar información para detectar irregularidades. Según la CEPAL (2017), para que esto sea posible es necesario extender el uso y obligatoriedad de este mecanismo de facturación, lo cual requiere garantizar previamente condiciones de acceso y operabilidad de los servicios informáticos asociados. Los modelos de factura electrónica más efectivos son aquellos con reportes en tiempo real que permiten la validación previa por parte de la administración tributaria. Actualmente, 10 de 18 países de América Latina aplican la factura electrónica de manera obligatoria.
15. **Validaciones internas y externas.**
    1. Existe una enorme gama de estudios de impacto de la Factura electrónica disponibles en internet (Chile, Brasil y México), comprobando la efectividad del uso de este instrumento en el aumento de recaudaciones tributarias. Entre estos estudios, merecen especial mención aquellos sobre la “Nota Fiscal Electrónica” implementada en los 27 estados de Brasil y el Distrito Federal, los cuales de forma unánime comprueban que este tipo de instrumento tributario tuvo un impacto positivo en el aumento de la recaudación del IVA en Brasil (conocido en el país como ICMS[[4]](#footnote-4)). Cabe destacar que la implementación de la F-e en Brasil fue apoyada por el Banco a través de la Línea de Crédito Condicional (CCLIP) para el Programa de Apoyo a la Gestión e Integración de los Fiscos en Brasil (PROFISCO BR-X1005), el cual fue aprobado por el Directorio Ejecutivo por medio de la Resolución DE-132/08 del 5 de noviembre de 2008[[5]](#footnote-5). Se incluye como referencia una de las evaluaciones de impacto disponibles, la del Programa Nota Fiscal Paulista, la cual presenta en su conclusión que el Programa generó un impacto positivo y estadísticamente significativo sobre la recaudación real del ICMS en el estado de São Paulo del orden de R$600 millones, representando 12% de la media recaudada por el estado después de su implantación hasta el mes de octubre de 2014[[6]](#footnote-6).
16. **Metodología**
17. **Descripción**
    1. En el anexo se describe en detalle la derivación de las ecuaciones del modelo. El modelo representa una economía pequeña y abierta con tres sectores productivos: el sector transable, el no-transable y el sector encargado de la explotación de un recurso natural (petróleo). Cada uno de los tres sectores emplea capital y trabajo y compran insumos intermedios de los otros sectores productivos y del exterior. La estructura productiva de la economía y la interdependencia cuantitativa entre los distintos sectores económicos replican una versión estilizada de tres sectores de la matriz insumo-producto colombiana. La economía está habitada por un continuum de familias heterogéneas (Ricardianas y no-Ricardianas -familias que solo reciben ingreso laboral, no ahorran ni pagan impuestos), firmas que operan en competencia perfecta en los mercados de bienes y factores y un gobierno.
    2. De forma consistente con el objetivo de estudiar el diseño e impacto de diferentes políticas fiscales en el corto y mediano plazo, el gobierno ejecuta varias acciones en la economía. El gobierno grava la renta laboral (impuesto de renta de las personas naturales), la renta de capital (impuesto de renta de las personas jurídicas), los gastos de consumo (impuesto al valor agregado), las importaciones (aranceles) y la producción doméstica de bienes o productos (impuestos específicos o “excise taxes”). El gobierno recibe dividendos distribuidos por ECOPETROL, gasta en bienes no-transables, invierte en infraestructura física, y emite deuda en los mercados de capital interno y externo. El acervo de infraestructura está sujeto a congestión. Las políticas fiscales están especificadas en términos de trayectorias temporales exógenas y el modelo simula la respuesta de otras variables fiscales endógenas (ingreso tributario, por ejemplo) y el ajuste general que ocurre en la economía.
    3. El modelo consta de 85 ecuaciones no lineales. Una vez el modelo ha sido especificado, es necesario dar valores a los parámetros del modelo. Este proceso se llama calibración. El modelo contiene 57 parámetros. En el anexo se describe el proceso y, a manera de ejemplo, se calibra el modelo para Colombia y Perú. La estrategia de calibración es la misma para los dos países. Se supone que las dos economías están en su posición de estado estacionario en el año 2010, año para el cual se dispone de la última información sobre la matriz insumo-producto. Un periodo en el modelo corresponde a un año.
    4. A continuación, el sistema de 85 ecuaciones no lineales con expectativas racionales se log-lineariza alrededor del estado estacionario y el sistema se resuelve usando métodos numéricos estándar. La solución consiste en un sistema de ecuaciones lineales en diferencias que relacionan las 85 variables endógenas (consumo, inversión, PIB, tasa de crecimiento, exportaciones, importaciones, stock de infraestructura, deuda pública, déficit primario, etc.) con las llamadas variables de estado. Las variables de estado incluyen a las variables endógenas rezagadas y al conjunto de variables exógenas. Hay 21 variables exógenas. El vector de variables exógenas incluye, a grandes rasgos, variables del ciclo económico mundial (PIB global o de los mayores socios comerciales del país, tasa de interés externa y precios de *commodities*), choques tecnológicos domésticos y las variables de política fiscal. En resumen, la dinámica de la economía esta dada por el siguiente proceso lineal:

Donde es el vector de variables endógenas, es el vector de variables exógenas y y son matrices que dependen de los parámetros del modelo. Dado un punto de partida (año 2010 o estado estacionario) y dada la trayectoria de la variable o variables exógenas desde el año 2010 hasta el horizonte deseado de proyección (año 2020, por ejemplo) , es posible calcular la respuesta de la economía descrita por la trayectoria de las 85 variables endógenas .

* 1. Ejemplo: Supongamos que queremos ver el efecto sobre las finanzas públicas (balance primario y deuda neta del gobierno) del choque adverso reciente de precios de “commodities”. En el modelo, este choque es capturado por dos variables exógenas: el precio real del *commodity* y los ingresos no-tributarios provenientes de la explotación del recurso natural (regalías mineras en el caso de Perú y distribución de dividendos de ECOPETROL en el caso colombiano). El gráfico siguiente muestra la trayectoria de ambas variables. El precio real del *commodity* proviene de las bases de datos históricas y de proyecciones de precios del Banco Mundial. La información sobre ingresos no tributarios proviene del *Marco Fiscal de Mediano Plazo* (2017) (MFMP (2017)) para Colombia y del *Marco Macroeconómico Multianual 2020-2021* (2017) (MMM (2017)) para el Perú. El MFMP trae proyecciones a 10 años mientras que el MMM trae proyecciones a 4 años.



Note que en este experimento hemos supuesto que no hay reacción de la política fiscal al choque en el mercado de *commodities*. El gasto discrecional del gobierno (gasto de consumo y gasto de capital) se supone constante en el nivel, relativo al PIB, de 2010. Aquí solo operan los estabilizadores automáticos a través del efecto estabilizador de tasas constantes de tributación. La figura que se incluye a continuación registra el comportamiento esperado del superávit primario y de la deuda pública a lo largo del horizonte de simulación. El modelo muestra que si los gobiernos hubieran dejado operan los estabilizadores automáticos, es decir, si hubieran ahorrado toda la bonanza, habrían logrado elevar el superávit primario y, por lo tanto, reducir la deuda pública como porcentaje del PIB. Si no se hubiera producido el choque adverso de precios, la deuda y el déficit se habrían mantenido constantes al nivel inicial de 2010, el nivel de estado estacionario. La comparación de los dos escenarios permite estimar el efecto del choque exógeno sobre el comportamiento de la economía.



* 1. En la evaluación que aquí se propone se procederá de manera similar al ejemplo. Se estimará la trayectoria temporal de la variable exógena - la tasa efectiva de tributación de IVA - y se usará el modelo para estimar el efecto sobre la evolución del déficit fiscal y la deuda pública. Se usará el resultado del ejercicio de Evaluación con base en un Control Sintético para la construcción de la trayectoria de la variable exógena entre 2017 y 2020. Específicamente, el ejercicio de control sintético permite estimar los mayores ingresos de IVA en relación con el pool de donantes que no recibieron el “tratamiento” de la F-e. Con los datos de mayores ingresos de IVA explicados por el “tratamiento”, se construirá la senda temporal de la tasa efectiva de tributación de IVA. La calibración del modelo se actualizará en la medida que se disponga de información más reciente, particularmente, de la matriz insumo producto.

**Anexo 1: The Model**

# Introduction

The FMM-MTFF model is a small open economy dynamic general equilibrium model that attempts to feature the main characteristics of economies in the LAC region. The model is primarily intended to serve as a simulation tool to study the effect of fiscal policies.

# The FMM-MTFF Model

The model represents a small open economy that has three interdependent production sectors: traded goods, nontraded goods, and a natural resource-based commodity[[7]](#footnote-7). The individual industries employ capital and labor and purchase intermediate inputs from other producing sectors and overseas. The production structure of the economy and the quantitative interdependence between interrelated economic activities replicate a three-sector stylized version of a country’s input-output (I-O) table. The economy is inhabited by a continuum of heterogeneous families (Ricardian and non-Ricardian), as in Galí et al. (2004) and (2007), by firms operating in perfect competition in factor and goods markets, and by a government.

Consistent with the objective of studying the design, behavior and impact of general fiscal policies over the medium term, the government performs several actions. The government levies taxes on labor income, capital income, consumption expenditures, imports, and on domestic products/production; receives dividends or royalties from the natural resource-based industry, spends on nontraded goods, invests on infrastructure capital, and issues debt in domestic and external capital markets. Public capital is subject to congestion, as in Gloom and Ravikumar (1994) and (1997), though there is no endogenous growth. Fiscal policies are specified in terms of exogenous trajectories and the model simulates the response of other endogenous fiscal aggregates and the adjustment that occur to the economy.

To save on notation the model economy is directly presented in its stationary intensive form. Given appropriate restrictions on preferences and technologies and after removing the built-in random walk property of the equilibrium dynamics proper of a small open economy, the transformed economy exhibits a well-defined steady state balanced growth equilibrium. Real per capita flow variables are detrended by dividing by , the deterministic component of productivity with representing the gross rate of growth of labor-augmenting technical progress, which in turn determines the long-term growth of output per capita. Real per capita stock variables accumulated until the end of period are detrended by . There is no need to detrend the per capita labor input. After the solution to the stationary model is constructed, nonstationary per capita aggregates can be recovered by using the inverse transformation and comparable levels to NIPA and other aggregate macro variables can be obtained by multiplying through by the working age population (ages 15-64). Domestic prices are normalized by the price of the numeraire, the price of the composite consumption basket. The real exchange rate is defined as the price of one unit of the foreign consumption basket in units of the domestic one; the world relative prices of oil and imports are defined as the corresponding world prices relative to the foreign consumption price and their domestic counterparts are given by and , respectively.

## The Production Side

**Figure 1** provides a graphical representation of the production structure. The figure shows the flow of transformation processes through which inputs are converted into outputs along the various stages of production, from primary production in the top tier of the figure to final use in the bottom part. In the upper layer of activities, gross output is produced by the three industries and all industry-to-industry intermediate transactions, including the purchases of raw materials and intermediate inputs abroad, are carried out. The commodity sector output is partly sold locally to intermediate users in the (small) amount dictated by the input-output table but, in fact, most of it is exported at the world price. The nontraded sector good is in part directly sold for government consumption, also consistent with the I-O matrix, and the rest is combined with (non-resource) traded goods to produce the domestic good. Then, the composite domestic good is used, along with either imports of capital goods and equipment or consumption goods, as input in the production of an investment good and a consumption good. The investment good is accumulated into sector-specific stocks of private capital and productivity-enhancing infrastructure. The composite numeraire good is consumed domestically or exported.

### Sectoral Industries

There are three production sectors ,, in the economy where represents sectoral gross output and is the corresponding domestic relative price. Sector is the (non-resource) traded sector, sector is the nontraded good producing sector and represents the natural resource sector.

**Figure 1**



Each sector uses a Leontief technology:

|  |  |  |
| --- | --- | --- |
|  |  | [1] |
|  |  | [2] |
|  |  | [3] |

The production function is separable in value added and intermediate inputs and the value-added component is a function of the end-of-period private capital stock , labor and the level of productivity. is the private capital share in sector value added. stands for an aggregate technology shock around the long-run deterministic level of productivity that affects all sectors simultaneously and represents an idiosyncratic technology shock to sector . is the amount of input from sector , , needed to produce the output of sector and parameters represent technological input requirements, i.e., the quantity of input required per unit of gross output . Similarly, represents the demand of imported intermediate goods needed to produce sector gross output and is the corresponding input coefficient.

Government-supplied infrastructure, , enhances private sector productivity where is the output elasticity of public capital. Public capital is subject to congestion (Gloom and Ravikumar (1994) and (1997)) with , , governing the degree of congestion. This production externality depends not on the level of infrastructure capital but on the ratio of infrastructure to adjusted private capital, the “effective” stock of infrastructure, . When , infrastructure capital services qualify as a pure public good (non-excludable and non-rival). When , congestion effects come into play. An increase in public infrastructure boosts private sector productivity but this effect fades away as the stock of infrastructure decreases relative to the level of private sector activity, proxied here by the stock of private capital installed. In the extreme case of , capital infrastructure services can be regarded as a pure private good (rival and excludable). Uppercase letters have been used in the definition of the effective stock of infrastructure (equation [2]) to denote the fact that firms take aggregate sectoral capital stocks as given, i.e., they do not internalize the effect of their investment decisions on congestion. is a scale parameter and the condition is imposed to rule out endogenous growth.

The representative firm in sector chooses capital , labor services , domestic intermediate inputs e imported intermediate inputs , to maximize the discounted sum of profits, taking prices and taxes as given,

|  |  |  |
| --- | --- | --- |
|  |  | [4] |

and subject to the fixed proportions technological constraint [1]-[3]. is the stochastic discount factor, is the Lagrange multiplier associated with the budget constraint in the Ricardian household problem (aggregate version of equation [29]) and is the conditional expectations operator. is the subjective discount factor and is the effective tax rate on sector output. is the wage rate and is the rental rate on sectoral capital, both measured in terms of the numeraire. Net returns to capital are equalized across sectors but wage equalization in the steady state is not imposed by the model. The last term in [4] introduces quadratic labor adjustment costs (Sargent (1978)). The rapid adjustment of employment has a cost in terms of forgone output where governs the magnitude of output loss in sector .

The first order conditions of the firm’s problem in sector i, , are given by:

|  |  |  |
| --- | --- | --- |
|  |  | [5] |
|  |  | [6] |
|  |  | [7] |
|  |  | [8] |
|  |  | [9] |
|  |  | [10] |
|  |  | [11] |

By the law of one price, the commodity sector price is tied to its price abroad: . Similarly, the price of the imported intermediate good is equal to its corresponding world price measured in the home numeraire unit: . In the model, agents can import consumption, capital, and intermediate goods. For simplicity, they are assumed to share the same price.

### The Domestic Good

The domestic good is produced by combining (non-resource) traded goods and nontraded goods according to a constant elasticity of substitution (CES) technology with substitution parameter ,

|  |  |  |
| --- | --- | --- |
|  |  | [12] |

is a scale parameter and is the share of traded goods in the domestic good basket. The producer firm of the domestic good chooses and to maximize profits:

|  |  |  |
| --- | --- | --- |
|  |  | [13] |

subject to [12] and where is the price of the domestic good. The optimal demand functions for traded and nontraded good inputs are given by:

|  |  |  |
| --- | --- | --- |
|  |  | [14] |
|  |  | [15] |

And the corresponding price index is given by the zero-profit condition:

|  |  |  |
| --- | --- | --- |
|  |  | [16] |

### Investment and Consumption Good Producers

The investment good and the consumption good are produced by combining domestic goods and imports in an Armington aggregator production function with constant elasticity of substitution parameters and . The firm producing the investment good solves the following static optimization problem:

|  |  |  |
| --- | --- | --- |
|  |  | [17] |

subject to:

|  |  |  |
| --- | --- | --- |
|  |  | [18] |

while the problem of the consumption good producing firm can be written as:

|  |  |  |
| --- | --- | --- |
|  |  | [19] |

subject to:

|  |  |  |
| --- | --- | --- |
|  |  | [20] |

The domestic good is wholly consumed in the production of the investment good in the amount and in the production of the consumption good, in the amount . Imports of capital goods, machinery, and equipment are inputs into the production of the composite investment good and imports of consumption goods are used by domestic firms to produce the composite consumption good. Consumption good imports are subject to tariff duties, consistent with I-O accounts, where is the exogenous effective tariff rate. In addition to standard input demand and investment price functions (see Annex 1 for a full list of the model equations), the numeraire good satisfies the following price condition, :

|  |  |  |
| --- | --- | --- |
|  |  | [21] |

## Households

The total number of households is normalized to 1. Following Galí et al. (2004) and (2007), a fraction of households are Ricardian households, which have access to capital markets and adjust savings optimally in response to changing economic conditions, and a fraction are non-Ricardian households, households which do not have access to a savings technology and just consume their labor income. Ricardian households, denoted by superscript O, have access to domestic and international bond markets to save and borrow, have access to a physical capital market, and optimize over their lifetimes.

The restricted type of households is denoted by superscript NO. The representative non-Ricardian household only earns wage income from supplying labor services to each producing sector and does not pay taxes. Non-Ricardian consumption is determined by the budget constraint:

|  |  |  |
| --- | --- | --- |
|  |  | [22] |

where denotes government transfers. The non-Ricardian household’s period utility function is given by:

|  |  |  |
| --- | --- | --- |
|  |  | [23] |

where is the inverse of the Frisch elasticity of labor supply, is the inverse of the intertemporal elasticity of substitution and measures the degree of disutility from working in sector . These are GHH preferences (Hercowitz et al. (1988)) which imply that labor supply depends only on the real wage, precluding wealth effects. However, the lack of an income effect is inconsistent with balanced growth. To ensure consistency, the disutility of labor has been assumed to growth with technological progress (Jaimovich and Rebelo (2009) preferences). The optimal labor supply decision associated with the utility maximization problem subject to the budget constraint [22] is:

|  |  |  |
| --- | --- | --- |
|  |  | [24] |

The representative Ricardian household maximizes its expected lifetime utility function

|  |  |  |
| --- | --- | --- |
|  |  | [25] |

These preferences featuring external habit persistence, where the period utility depends on the quasi-difference of consumption, are used to introduce an internal persistence mechanism in the consumption process. denotes the intensity of the habit formation. Again, the notation (uppercase letters) highlights the fact that habit formation is an externality and that the household does not internalize the effect of its consumption-saving decisions on the habit level.

The Ricardian household’s optimization problem is subject to the following budget constraint and the laws of motion for physical capital accumulation in the three production sectors:

|  |  |  |
| --- | --- | --- |
|  |  | [26] |
|  |  | [27] |

The intertemporal optimizing household spends on consumption and investment goods; earns real wage income , capital income , and interest income on government bond holdings paying a gross real interest rate ; receives lump-sum transfers from the government and profit distributions in the form of real dividend payments as owner of all firms of the economy. It also transfers part of the commodity sector capital income to the government in the form of royalties and pays taxes on labor income , capital income net of depreciation , and consumption expenditures . The household can borrow from international capital markets by paying a gross interest rate: . The first component of this expression is the government’s gross borrowing rate in international markets, to be specified further below, and the second component is a debt elastic interest rate premium. This premium is taken exogenously by the representative agents and is assumed to be an increasing function of the aggregate stock of private external debt relative to its steady state level . This interest rate specification is used to induce stationarity in small open economy models (Schmitt-Grohé and Uribe (2003)).

is the relative price of the investment good in terms of consumption and the investment good accumulates into sector-specific capital stocks [27], making it costly to reallocate capital across sectors. The capital accumulation process in each sector is also subject to investment adjustment costs. is the depreciation rate of capital installed in sector and is an adjustment cost parameter.

The choice variables in the Ricardian household optimization problem are , , , , , and . Then, the optimal path satisfies the following conditions:

|  |  |  |
| --- | --- | --- |
|  |  | [28] |
|  |  | [29] |
|  |  | [30] |
|  |  | [31] |
|  |  | [32] |
|  |  | [33] |

and , , are Lagrangian multipliers associated with the budget constraint and the capital accumulation equations, respectively.

Finally, aggregating across households yields total household consumption and sectoral investment demands, labor supply and total transfers:

|  |  |  |
| --- | --- | --- |
|  |  | [34] |
|  |  | [35] |
|  |  | [36] |
|  |  | [37] |
|  |  | [38] |

as well as aggregate assets and liabilities holdings

|  |  |  |
| --- | --- | --- |
|  |  | [39] |
|  |  | [40] |
|  |  | [41] |

All transfers , expressed as a percent of GDP, and tax rates follow exogenous time paths.

## Government

Each period, the government invests where is the real amount of gross public investment in infrastructure. In terms of value, government capital spending satisfies the following condition:

|  |  |  |
| --- | --- | --- |
|  |  | [42] |

where -with an obvious empirical counterpart- is assumed to follow an exogenous process. is the GDP price index in terms of the consumption basket and is the GDP quantity index. Infrastructure capital investment accumulates following a standard law of motion with adjustment costs, where is the adjustment cost parameter and is the depreciation rate:

|  |  |  |
| --- | --- | --- |
|  |  | [43] |

In a similar vein, government spending on nontraded goods and services is governed by the variable which relates the value of government spending and GDP

|  |  |  |
| --- | --- | --- |
|  |  | [44] |

Government expenditures and revenues must satisfy the current period budget constraint. The government budget constraint is written as follows

|  |  |  |
| --- | --- | --- |
|  |  | [45] |
|  |  | [46] |
|  |  | [47] |

Abusing the notation slightly while understanding all magnitudes as aggregate variables, equation [45] defines the amount of government financing needs as the difference between total outlays, including amortization payments to cover interests and principal repayment, and total receipts. Equations [46] and [47] indicate that a fraction of the total financing needs is funded by issuing end-of-period domestic government bonds and the rest, , by borrowing abroad , where is determined exogenously.

The government’s cost of borrowing from abroad consists of an exogenously determined risk-free international interest rate and an endogenous risk premium

|  |  |  |
| --- | --- | --- |
|  |  | [48] |

The interest rate premium depends on the ratio of external government debt to GDP, where is the corresponding steady-state ratio:

|  |  |  |
| --- | --- | --- |
|  |  | [49] |

is a scale parameter governing the steady-state level of the sovereign spread and measures its responsiveness to foreign government debt.

## Exports, Imports, and Terms of Trade

The country’s export basket comprises natural resources and a composite consumption good . The whole production of the natural resource-based commodity is exported, once domestic intermediate needs are satisfied. The (semi-small open) economy faces a downward-sloping demand function for its non-resource export good. The export demand is defined as in Kollmann (2002):

|  |  |  |
| --- | --- | --- |
|  |  | [50] |

where is the (absolute value of the) price elasticity, is the elasticity with respect to foreign real GDP, which is assumed to capture aggregate demand developments across the country’s trading partners and is a scale parameter. is assumed to follow an exogenous process. Aggregate export price and quantity indexes are constructed as Cobb-Douglas aggregates of natural resource and non-resource export prices and bundles:

|  |  |  |
| --- | --- | --- |
|  |  | [51] |
|  |  | [52] |

where is the expenditure share on non-resource goods in the base period.

Trade balance , total imports and terms of trade are defined as follows:

|  |  |  |
| --- | --- | --- |
|  |  | [53] |
|  |  | [54] |
|  |  | [55] |

## National Income Accounting

A change in world export prices is treated as a price phenomenon in national income and product accounting. However, the usual practice is to define real GDP as the value of the final demand side components divided by the GDP deflator (see for example, Medina and Soto (2016)), in which case a commodity price shock can have a direct real effect. The effect of import and export prices on income and welfare is better captured by the notion of real GDI, gross domestic income. Even though real GDP is a misleading indicator that underestimates the benefits arising from trading gains, the objective here is to embed in the model a GDP measurement framework that is consistent with what national account compilers do.

There are two approaches for estimating a volume index of GDP: fixed base year and annual chaining[[8]](#footnote-8). Both approaches will be used in the empirical applications. As a Laspeyres type volume index, the first method -the “fixed weight” measure of real GDP- values all quantities through time at the set of prices prevailing in the base year:

|  |  |  |
| --- | --- | --- |
|  |  | [56] |

All prices are set to unity in the base year. The use of a reference price structure gives rise to the so-called “Gerschenkron effect” where a change in the base year may alter the estimated growth rates of the volume index. In the second approach, when indexes are chained, the previous year is used as the base year. The GDP volume index level evolves according to the following law of motion

|  |  |  |
| --- | --- | --- |
|  |  | [57] |

Setting an arbitrary base year, for which nominal and real GDP are equal, the volume index is constructed by chaining together successive links from the base year:

|  |  |  |
| --- | --- | --- |
|  |  | [58] |

The link of the chain is the gross rate of real GDP growth in each period. This is a chained Laspeyres volume index (period prices used as weights). The GDP deflator in terms of the numeraire satisfies:

|  |  |  |
| --- | --- | --- |
|  |  | [59] |

implying a chained Paasche price index. Note, however, that the proposed accounting framework is not entirely consistent with national accounting practices. GDP at market prices includes indirect taxes and their effect is not being considered by equation [58].

## Market Equilibrium Conditions and Dynamic Stability

In equilibrium all markets in the economy clear in each period. At the sectoral level, labor supply and demand for labor services satisfy:

|  |  |  |
| --- | --- | --- |
|  |  | [60] |

The market clearing conditions for the various good markets are:

|  |  |  |
| --- | --- | --- |
|  |  | [61] |
|  |  | [62] |
|  |  | [63] |
|  |  | [64] |
|  |  | [65] |
|  |  | [66] |

Combining households budget constraints, the government budget constraint, defining profits for all producing firms and using market clearing conditions, the national resource constraint is given by the balance of payment condition

|  |  |  |
| --- | --- | --- |
|  |  | [67] |

Finally, to ensure the dynamic stability of public debt, but only in the very long run, a switching rule is implicitly adopted:

|  |  |  |
| --- | --- | --- |
|  |  | [68] |

where is an indicator function that takes on a value of for at least up to the desired forecast horizon (typically 10 years) and a value of thereafter. During the initial periods, the path of government expenditures, relative to GDP, is conditioned by an arbitrary, exogenous path and then it switches to a regular fiscal rule that stabilizes the government debt-to-GDP ratio to its long-run target . In principle, feedback fiscal rules can be defined for other instruments: lump-sum transfers, government investment or taxes.

Annex 1 contains the full list of the model equations written in terms of detrended variables for which a deterministic steady state can be computed.

# Calibration and Steady State

Once the model equations are fully specified and functional forms parameterized, parameter values are then assigned, and deterministic steady states computed for Colombia (COL) and Peru (PER). The calibration strategy is the same in each country case. The two economies are assumed to be sitting at their initial steady state in 2010. The steady state value of any variable is represented hereafter by dropping the time index. Annex 2 shows the system of steady state constraints imposed by the deterministic stationary state of the economy. One period in the model is taken to be one year. Two information sets are used to completely calibrate the model economies. The first is the country’s stylized version of the 2010 input-output (I-O) table (Table 1) constructed from tables compiled by the OECD.[[9]](#footnote-9) (Detrended per capita) GDP at market prices has been normalized to 100 in the 2010 I-O table so that matrix entries can be interpreted as percentages of GDP. The second is Table 2 which provides additional aggregate targets (as of 2010) and parameter estimates directly taken from applied econometric studies or other sources. The remaining parameters values are calibrated such that the system of steady state relations is satisfied.

The 34 industries of the original I-O table are consolidated into three sectors: the traded sector, which consists largely of all manufacturing industries and agriculture; the nontraded sector which groups all service industries, and the natural resource sector, or Mining and Quarrying in the OECD nomenclature. Several adjustments were made to the original matrix. Without affecting the magnitude of GDP at market prices, taxes (less subsidies) on production are recorded as taxes (less subsidies) on products, rendering the definitions of gross value added at factor cost and at basic prices identical. Thus, value added reflects solely the contribution of capital and labor to production and the corresponding aggregate factor shares are obtained from NIPA data (aggregate labor share COL: 0.617 and PER: 0.572). Labor income is defined as the sum of compensation of employees and mixed income. In addition, some entries of the I-O matrix, generally small, were set to zero to make the input-output matrix consistent with the model specification. Such is the case of government spending on traded goods (COL and PER: ~0% of GDP), the final use of the natural resource as an investment good (COL: 0.09% and PER: 0.06% of GDP), nontraded sector exports (COL: 0.67% and PER: 1.05% of GDP), taxes on export goods (COL: 0.05% and PER: 0.08% of GDP), taxes on government spending (COL and PER: ~0% of GDP) and re-exports of imported goods (COL: 0.24% and PER: ~0% of GDP). These adjustments give rise to an unbalanced I-O matrix, a problem handled by using the RAS balancing method (Stone (1961) and Stone and Brown (1962)). Rebalanced I-O matrices are displayed in Table 1.

* *Steady state values of endogenous and exogenous variables*. Domestic GDP at market prices is chosen such that and all relative prices are set equal to unity in the steady state:

|  |  |  |
| --- | --- | --- |
|  |  |  |

By employing these assumptions together with Tables 1 and 2, steady state values for all national accounting aggregates and public and private debt levels are computed. Based on the average empirical estimates reported by López and Ortega (1998), the fraction of liquidity-constrained households is used to estimate Ricardian and non-Ricardian consumption aggregates. By setting wages to unity, indexes of labor input at aggregate and sectoral levels can be retrieved directly from the I-O table. Ricardian and non-Ricardian households are assumed to work for the same amount of time in the initial steady state.

Regarding the 21 exogenous variables, their steady state values are computed as follows. Steady state technology levels are normalized to unity , as well as exogenous relative prices . The scale variable in the export demand equation is normalized at . The international gross interest rate is set to , which is implied by the domestic real interest rate and country risk premium used by Schmitt-Grohé and Uribe (2016) and Uribe and Yue (2006). The nominal ratios of government consumption spending to GDP () and government investment to GDP are obtained from I-O tables and NIPA data, respectively. The share of domestic government debt is set to 0.687 for COL and 0.48 for PER, based on information on public debt stocks by currency of denomination in year 2010 (see Table 2).

**Table 1: 2010 Input-Output Tables**



**Table 2: Calibration Targets and Basic Parameter Values for Colombia and Peru**



Effective tax rates are computed by the quotient of the specific tax revenue and the corresponding tax base. Consistent with revenue data (Tables 1 and 2), the following tax rates are calibrated:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| COL | 0.0126 | 0.0084 | 0.0039 | 0.2486 | 0.1818 | 0.0477 | 0.1089 |
| PER | 0.0084 | 0.0066 | 0.0051 | 0.3395 | 0.0369 | 0.0847 | 0.1260 |

Finally, lump-sum transfers are set to zero and the percentage of GDP of non-tax revenues from natural resources is calibrated at for COL and for PER, based on data reported for year 2010 in the *Marco Fiscal de Mediano Plazo 2017* (2017) and the *Marco Macroeconómico Multianual 2018-2021* (2017), respectively.

Gross growth rate factors are set at for COL and for PER, reflecting the 1990-2010 average per capita growth rates. GDP in constant local currency and population aged 15-64 figures are obtained from the IMF’s World Economic Outlook (WEO) and World Bank’s World Development Indicator datasets, respectively. The stock of public infrastructure capital is estimated from the equilibrium capital accumulation equation in steady state (Annex 2, equation A37). Here, the depreciation rate of public capital is assumed to be , following the IMF (2015)’s estimate for middle-income countries. Private investment is defined as the difference between total investment (from I-O table) and public investment (from national accounts). Total private capital stock is obtained from the aggregate version of equilibrium conditions [A23] and [A26] and aggregate gross operating surplus (I-O table). The sectoral distribution of the private capital stock is assumed to match the sectoral distribution of gross operating surplus, entailing identical rates of return on private physical capital and depreciation rates across sectors in the initial steady state. I got for COL and 0 for PER.

* *Production technologies*. There is a fixed proportions technology to produce each sector gross output whose arguments are value added and intermediate goods. In calibrating the value-added component, the elasticity of output with respect to infrastructure capital is set at following Calderón et al. (2014) and Bom and Ligthart (2008). The congestion parameter is fixed at as suggested by Rioja (2004). Sectoral capital shares in value added are estimated using I-O data on:

|  |  |  |
| --- | --- | --- |
|  |  |  |

Scale parameters , , are set to match sector sizes in the steady state and do not influence the log-linearized representation of the model. Regarding the intermediate goods component, first order conditions [A7] to [A9] define technical coefficients in terms of I-O data on intermediate input use, as the ratio of input of sector to sector output:

|  |  |  |
| --- | --- | --- |
|  |  |  |

Similarly, Leontief import coefficients are estimated from sectoral import demand functions [A10]. Table 3 presents the main calibrated parameter values.

The production functions for the domestic, investment and consumption goods are specified as CES or Armington CES composites of two inputs. The Armington elasticity of substitution between domestic and imported goods is set to 1.5 following Backus et al. (1994). As in Ostry and Reinhart (1992) the elasticity of substitution between traded and nontraded goods is set at . Share and shift parameters are calibrated from I-O data allocations and intratemporal equilibrium conditions [A12]-[A20] evaluated at the steady state.

**Table 3: Calibrated Parameter Values**



* *Preferences*. Parameter , the subjective time discount factor, is set to to ensure consistency with the real interest rate and growth rate factors as expressed by condition [A29]. The curvature parameter in the utility function is set to according to Mendoza (1991). is calibrated at 0.455 (Mendoza (1991)), which implies a Frisch elasticity of 2.2. The external habit formation parameter is calibrated to 0.20 following Uribe and Yue (2006). The disutility weight parameters and are chosen to match sectoral hours worked of Ricardian and non-Ricardian households and labor supply elasticity according to conditions [A24] and [A22], respectively.
* *Stochastic structure*. All exogenous variables, expressed either as absolute deviations or log-deviations from trend[[10]](#footnote-10), are assumed to follow simple stationary AR(1) processes, with shocks drawn from independent normal distributions. Of relevance for the experiments conducted in the next section is the autocorrelation parameter associated with the natural-resource commodity price process. Fernández et al. (2017) compute a serial correlation coefficient of 0.47 for the world real price of fuel and 0.52 for metals. Accordingly, the AR(1) parameter, , is calibrated at 0.47 for COL and PER. Based on frequently used calibrations in the literature, productivity shocks are assumed to be highly persistent . The persistence parameter for the aggregate foreign output, , is set at 0.75 following Aguiar and Gopinath (2007) who estimate it at 0.75 for the average of developed countries and at 0.76 for the average of emerging market economies. The persistence parameter for the foreign interest rate is set at 0.81 adopting Neumeyer and Perri (2005)’s regression estimate. The lack of available and/or reliable data and the lack of empirical estimates are a major hindrance to calibrate other shock processes. It is well-known that models like the one specified here have a weak internal propagation mechanism to transform temporary shocks into highly persistent output responses. Aggregate output essentially inherits the persistence of the exogenous processes. To avoid failing in this regard, the persistence parameter for the remaining exogenous variables is set at 0.50, the persistence parameter for per capita GDP estimated by Agénor et al. (1999).

# Policy Experiment

The nonlinear rational expectations model is log-linearized around the deterministic steady state and solved using standard numerical techniques. The solution consists of a set of linear difference equations relating the current endogenous variables to the state vector - a vector containing the exogenous variables and some lagged endogenous variables. The economy is driven multifariously by a vector of forcing variables (listed in Table 4) which includes world business cycle and price shocks, domestic technology shocks, and fiscal policy shocks.

The experiment conducted in this section seeks to illustrate the use of the model as a tool to quantify the scale of the fiscal challenges, to provide consistent medium-term macroeconomic and fiscal projections and to assess the quantitative implications of past reforms and alternative fiscal policy options on the economy over the short and medium term. The operation of the model is illustrated with the experiences of Colombia and Peru. Both countries have long ago adopted and consolidated a medium term fiscal framework with forecasting horizons of four years for Peru and ten years for Colombia. These two countries, along with the IMF, as part of the responsibility for surveillance under Article IV of the IMF’s Articles of Agreement, provide publicly available forecasts for all major fiscal aggregates and for a few macroeconomic variables (i.e., GDP growth rates). All are updated annually on a rolling basis. In the case of Peru, the Fiscal Council is required to deliver non-binding opinion on the MTFF (forecasts, assumptions, targets, debt sustainability analyses and fiscal risk assessments) and its revisions.

Both economies are highly dependent on commodities with substantial mineral or hydrocarbon sectors and both were hardly hit by the most recent collapse of commodity prices. The commodity price bust began in mid-2011 and has been the main driving force behind the business cycle. After more than half a decade into persistently low commodity prices, both countries are still struggling to restore growth and rebalance it toward non-natural resource sectors. Government budgets have been adversely impacted as commodity-related revenues and economic activity promptly reflected the effect of weak commodity markets. Before considering policy responses and the effects of subsequent fiscal consolidation efforts, the first experiment is intended to simulate the impact on public finances of the most recent collapse in commodity prices. The simulated macrofiscal aggregates are obtained by feeding into the model a commodity price trajectory that replicates the actual realization from 2010 through 2016 and its expected path afterwards, as forecast by the World Bank.

**Table 4: List Exogenous Variables in the Model**



Besides calibration differences pointed out in the preceding section, the two countries differ in two additional respects. First, fiscal targets, ceilings and projections specified in the MTFF, in the fiscal rule, and in other fiscal instruments (annual budget, for example) are designed to cover the general government sector in Peru while in Colombia coverage is circumscribed to central government operations. Accordingly, some model’s definitions of fiscal aggregates are adjusted in the Colombian case to better approximate results for the central government level. Secondly, Peru uses the traditional Laspeyres “fixed-base year” measure while Colombia uses a Laspeyres “chain-weighted” procedure to measure GDP growth. The model’s real GDP accounting is adjusted accordingly (see section 1.E).

Experiment: Fiscal impact of the recent boom-bust commodity price cycle

Strictly speaking, a commodity price shock in the model is described by two related exogenous processes: the world relative price of the commodity good, , and the government non-tax revenue receipts from the commodity sector as a percentage of GDP, . For Peru, the commodity price is calculated as the weighted average of cooper, tin, iron ore, gold, silver, lead, zinc, crude oil and natural gas prices, weighted with the average export shares for 2010-2016. The Colombia weighted average includes prices of coal, crude oil and ferronickel (nickel). Average commodity prices are deflated by the US Consumer Price Index (CPI) and normalized to unity in 2010. The source for commodity price data, both historical (2010-2016) and forecasts (2017-2028), is the World Bank’s *Commodity Markets Outlook*; for the US CPI, is the IMF’s *World Economic Outlook* (WEO) database (October 2017) from 2010 to 2022 and extrapolation up to 2028 using the inflation rate implicit in the WEO’s 2022 CPI forecast. Commodity export volumes are obtained from the central banks’ official websites (Banco de la República de Colombia and Banco Central de Reserva del Perú). -processes are directly taken from Colombia’s *Marco Fiscal de Mediano Plazo* (2017) and Peru’s *Marco Macroeconómico Multianual 2018-2021* (2017). In the case of Peru, this variable mainly comprises mineral, oil and gas royalties levied by the general government on mining concessions while in the case of Colombia it corresponds to dividend payments to the central government from ECOPETROL, the large majority state-owned oil company which contributes with 65% of the oil exports.

Figure 2 depicts the behavior of the commodity price index in log-deviations from the steady state and non-tax revenues from natural resource extraction (relative to GDP) in absolute deviation from the 2010 steady state ratio. Despite differences in composition of the countries’ commodity production baskets, the recent boom-and-bust cycle is highly correlated. However, the boom-bust pattern seems to be more severe in the case of Colombia. The timing of non-tax revenues is also somewhat different. In Peru, royalty collection started falling in tandem with mineral prices since 2011 while, in Colombia, the distribution of ECOPETROL dividends peaked in 2013 and fell quite dramatically with the oil price collapse of 2015.

**Figure 2: Commodity Shock Processes: Non-Tax Revenues and Commodity Prices**



**Figure 3: Automatic Fiscal Response to the Boom-Bust Cycle**



In the pure commodity shock experiment the response of policy makers has been muted. Discretionary government spending is frozen at 2010 levels as a share of GDP. On the other hand, nondiscretionary fiscal policy plays a limited role in the stabilization of the business cycle through the automatic stabilizing actions of constant tax rates. Transfer payments to households, another automatic stabilizer, are set to zero in all experiments. Figure 3 shows the fiscal effect of the commodity price cycle. If prices and non-tax receipts had not changed, the government primary balance and government debt would remain constant at their 2010 steady state levels.

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1. En julio de 2015 el gobierno anunció el uso de una estrategia de Austeridad Inteligente para realizar un ajuste fiscal, de acuerdo con los requerimientos de la regla fiscal, priorizando el gasto social y dando espacio al sector privado para impulsar la inversión. [↑](#footnote-ref-1)
2. CEPAL (2017). Panorama Fiscal de América Latina y el Caribe 2017: la movilización de recursos para el financiamiento del desarrollo sostenible. [↑](#footnote-ref-2)
3. BID (2015). Estrategia País del BID para Colombia (2015-2018). [↑](#footnote-ref-3)
4. Impuesto sobre Circulación de Mercancías y Servicios (ICMS) [↑](#footnote-ref-4)
5. [CCLIP Para el PROFISCO (Respaldo a la Gestión e Integración de las Administraciones Financieras en Brasil)](http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1779520) [↑](#footnote-ref-5)
6. [Impacto del Programa Nota Fiscal Paulista en la expansión de la Recaudación Tributaría del Estado de São Paulo](http://www.revistaespacios.com/a15v36n17/15361703.html) [↑](#footnote-ref-6)
7. Throughout the paper the term “oil” will be used as a shorthand for the natural resource sector. Also “mining” is used to better describe the sector in a country application. [↑](#footnote-ref-7)
8. The IMF’s WEO database, Table G, provides a list of countries using the chain-weighted method. [↑](#footnote-ref-8)
9. See: <http://www.oecd.org/trade/input-outputtables.htm> [↑](#footnote-ref-9)
10. For the following exogenous variables AR(1) processes are defined in terms of absolute deviations: , , , , , ,, , , ,, , and . [↑](#footnote-ref-10)