Latin America's Declining Skill Premium: A Macroeconomic Analysis[†]

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Abstract

I find that the decline in Latin America's skill premium and income inequality during the 2000s was partly driven by an economic expansion that favored low-skill-intensive service sectors. Regression analysis with panel data shows inequality is acyclical prior to the 2000s, but countercyclical thereafter. Moreover, and unlike previous expansions, the boom of the 2000s was concentrated on services while manufacturing lagged behind. I build a small open economy general equilibrium model that features a low-skill-intensive nontradable sector relative to the tradable sector. When the model economy is buffeted by favorable shocks to commodity prices and international interest rate spreads, as was the case of Latin America in the 2000s, the skill premium falls by about a fifth of what is observed in the data.

JEL classification codes: D31, E32, F41, O15, O54.

Keywords: Latin America, skill premium, income inequality, business cycle, sectoral allocation, small open economy.

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1 Introduction

At least since the first half of the 20th century, Latin America has been the most unequal region in the world (Williamson (2010)). It is well known, however, that income inequality declined substantially within most countries during the 2000s, and that it was mainly driven by a decline in the skill premium—the gap between high-skilled and low-skilled wages. (Lustig et al. (2016), López-Calva and Lustig (2010)). Figure 1 shows the evolution of Gini indices on market and net income in 14 Latin American countries (median values). The Gini index on market income (pre-tax, pre-transfer) fell from about 53.8 in the early 2000s to 48.4 in 2011, a decline of approximately 10 percent.[1,2] As figure 1 shows, this was not the case before the 2000s. Indeed, Gasparini and Lustig (2011) document rising inequality during the 1980s and 1990s, and a reversal in the 2000s.

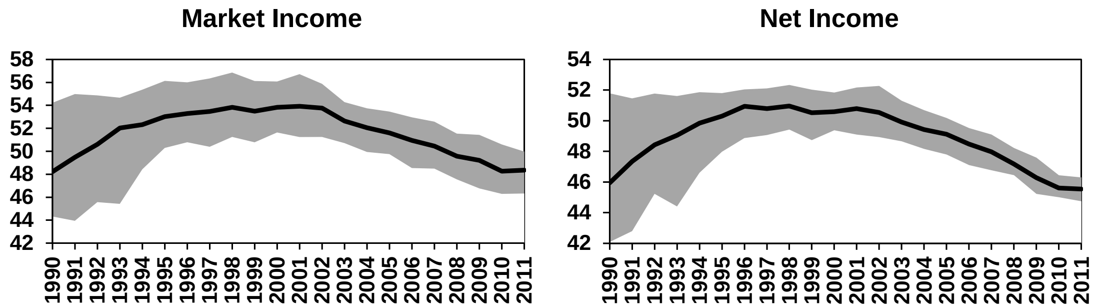
I find that the decline in Latin America's skill premium during the 2000s is partly driven by an economic expansion that favored low-skill-intensive service sectors, i.e., by an increase in the relative demand for low-skilled workers. Other papers point to an increase in the relative supply of high-skilled labor due to the expansion of educational enrollment and attainment (for example Azevedo et al. (2013a), and Cruces et al. (2011)). While there is no consensus on the exact role played by demand and supply forces on the dynamics of the skill premium, it is likely that both played a role (Lustig et al. (2016)). This paper contributes to this literature, which has mainly used microeconometric approaches, with a macroeconomic general equilibrium perspective on the underlying sources of the increase in the demand for low-skilled workers.

The booming 2000s were an unusual period. Regression analysis with panel data shows that inequality is acyclical prior to the 2000s, but countercyclical thereafter. Moreover,

[1] The Gini index on net income (after taxes and transfers) also fell approximately 10 percent, from about 50.6 in the early 2000s to 45.5 in 2011.

[2] The decline in income inequality in the 2000s is robust to other measures. Cord et al. (2017) document a decline in income inequality using growth incidence curves, income concentration indicators, the Theil index of inequality, the mean log deviation, the ratio between the 90th and the 10th percentile, and the Atkinson index.

Figure 1: Income Inequality in Latin America



Gini index on market income (pre-tax, pre-transfer) and net income (after taxes and transfers). Median values on 14 countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Honduras, Mexico, Panama, Paraguay and Peru. Solid lines are point estimates from SWIID; shaded regions denote 95 percent confidence intervals.

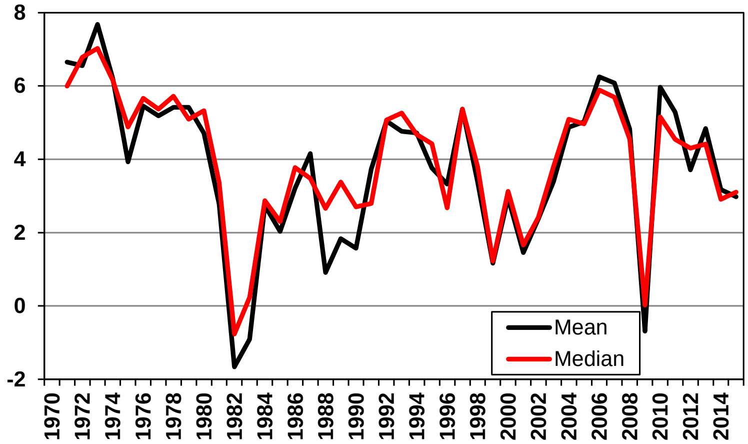
Source: The Standardized World Income Inequality Database v5.0, October 2014. See Solt (2016) for details.

and unlike previous expansions, the boom of the 2000s was concentrated on services while manufacturing lagged behind.

To understand and quantify the role of the economic expansion on the skill premium, I use a small open economy general equilibrium model that features a low-skill-intensive nontradable sector relative to the tradable sector. When the model economy is bufetted by favorable shocks to commodity prices and international interest rate spreads, as was the case in Latin America, the skill premium falls by about a fifth of what is observed in the data.

The boom of the 2000s came after two decades of low and volatile growth. Figure 2 shows mean and median values of real GDP growth across 14 Latin American countries from 1970 to 2015. The region recovered from the low growth of the late-1990s and early 2000s quickly; by 2004 it was growing at a rate of more than 5 percent, and growth would remain above that value until 2010, only briefly interrupted in 2009 by the effects of the global financial crisis. This was the longest period of high growth since the 1970s, the other period of regional expansion shown in the figure. It is widely believed that the expansion of the 2000s was fueled by a favorable international environment, with spectacularly high commodity prices (most Latin American countries are net exporters of commodities) and

Figure 2: Real GDP Growth in Latin America



In percent. See the note to figure 1 for a list of the countries considered.
Source: United Nations Statistics Division, March 2017.

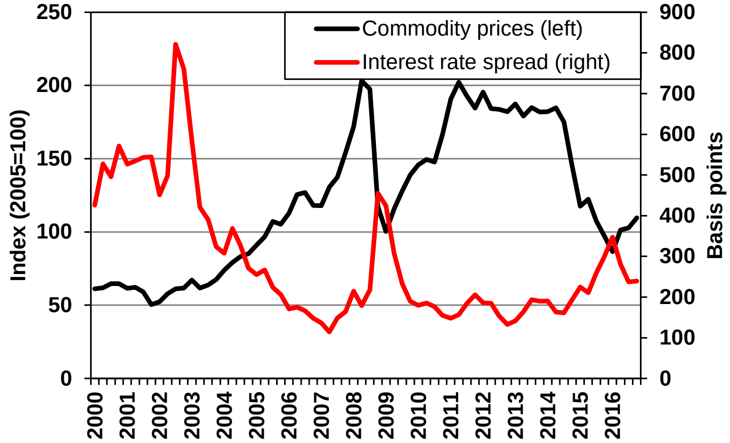
easy access to international financial markets.[3] Figure 3 plots the evolution of commodity prices and international interest rate spreads.

This paper appeals to cyclical forces to explain Latin America's declining inequality. Therefore, it implies that inequality should increase, or at least decline at a slower rate, during an economic downturn. Recent data support this prediction, as inequality has stagnated in Latin America at the same time that growth in the region has slowed. This phenomenon has been thoroughly documented by Cord et al. (2017) and the World Bank (2014).

The rest of the paper is organized as follows. The next section reviews additional related literature. Section 3 provides relevant evidence on the Latin American economy. Section 4 spells out the small open economy DSGE model. I discuss the calibration and estimation of the model in section 5, and put the model to work in section 6, in which I study and quantify the role of favorable international conditions and sectoral reallocation on the evolution of the skill premium. Section 7 concludes.

[3]See, for example, Izquierdo et al. (2008), Osterholm and Zettelmeyer (2008), and Fernández et al. (2015).

Figure 3: External Drivers of Latin America's Business Cycle



Global commodity price index compiled by the IMF. The interest rate spread is proxied by the EMBI spread; average for Brazil, Chile, Colombia, Mexico, and Peru.
Source: FRED Database and JP Morgan, March 2017.

2 Additional Related Literature

This paper is related to a strand of literature on the effects of resource allocation among tradable and nontradable sectors. Sectoral reallocation is central to the explanation of macroeconomic phenomena such as the so-called Dutch disease (Corden and Neary (1982), Corden (1984)), the role of terms-of-trade shocks as drivers of business cycles (Mendoza (1995)), and the macroeconomic effects of capital inflows (Benigno, Converse, and Fornaro (2015)). Little is known, however, about its role in explaining distributional issues. In the DSGE model developed in this paper, a shock that induces reallocation among the two sectors has an important effect on the skill premium, and by extension, on income inequality. Different skill intensities in the tradable and nontradable sectors lie at the heart of this effect. Other papers in which sectoral reallocation affects income distribution include Galiani, Heymann, and Magud (2010), and Coble and Magud (2010).

The paper is also related to a literature on income inequality over the business cycle focused on the United States.[4] It finds that inequality data display fluctuations at business

[4] García and Pérez (2016) offer an empirical analysis of income inequality over the business cycle for the

cycle frequencies and develops models to fit the data (Castañeda, Díaz-Giménez, and Ríos-Rull (1998), Maliar, Maliar, and Mora (2005), Barlevy and Tsiddon (2006)). Lindquist (2004) studies the evolution of the skill premium over the U.S. business cycle using a DSGE model that features capital-skill complementarity. I study the evolution of the skill premium in Latin America during the booming 2000s using a two-sector DSGE model that abstracts from capital accumulation.

As mentioned in the introduction, a recent literature, primarily microeconometric, analyzes the drivers behind the decline in income inequality in Latin America during the 2000s. A common finding is that *labor income* drives the decline in inequality, as opposed to sources of income such as government transfers, remittances, and pensions. More specifically, this literature finds that the *skill premium* is the key driver. Azevedo, Inchauste, and Sanfelice (2013b) estimate that labor income accounts for 54 percent of the fall in income inequality, whereas government transfers explain 21 percent. Azevedo et al. (2013a), Gasparini et al. (2011), Tsounta and Osueke (2014), and many other authors then argue that the falling skill premium is the cause of the equalizing effect of labor income, as opposed, for example, to a more equal distribution of skills. I contribute to this literature with a macroeconomic approach that sheds light on the underlying sources of the decline in the skill premium.

3 Motivating Evidence

This section documents that the relation between income inequality and the business cycle turned countercyclical in the 2000s (it was previously acyclical), and that the economic expansion during this period had a different sectoral composition than in previous booms, in the sense that it was concentrated on service sectors. This evidence lends support to the hypothesis that at least part of the decline in the region's inequality and skill premium was driven by the expansion of the 2000s.

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3.1 Income Inequality Over the Business Cycle

Panel regression analysis shows that prior to the 2000s, income inequality in Latin America is not related to the business cycle—it is acyclical, but in the 2000s inequality becomes countercyclical. In the baseline specification, I regress the Gini index (market income) on HP-filtered real GDP, controlling for country fixed effects. I consider an unbalanced panel of 14 Latin American countries for the period 1970–2013. The baseline panel regression is given by:

$$gini_{it} = \alpha + \beta y_{it} + \mu_i + v_{it}, \tag{1}$$

where $gini_{it}$ is the Gini index on market income for country i in year t, y_{it} is the percent deviation of real GDP from its HP trend in country i and year t (a proxy of the output gap), β is the coefficient that captures the relation between inequality and the business cycle, α is a common constant, μ_i are country fixed effects, and v_{it} is an error term.[5]

Table 1 presents the baseline results for the full sample (1970–2013) and two sub-samples: 1970–2000, and 2001–2013.[6] Columns (a) and (b) suggest the relation between the Gini index and GDP is economically and statistically insignificant, i.e., income inequality is acyclical, when considering the full sample and the sub-sample prior to the 2000s. Column (c), however, shows β is negative and statistically significant in the sub-sample 2001–2013: a 1 percent increase in (HP-filtered) real GDP is associated with a decline of 0.24 in the Gini index (-0.5 percent with respect to the common constant). That is, inequality is countercyclical in this period.[7]

These results are robust to: (a) using the Gini index on net income (as opposed to market

[5]Data on the Gini index come from the Standardized World Income Inequality Database (Solt (2016)). Data on real GDP come from the United Nations Statistics Division.

[6]I choose 2001 as the start of the second sub-sample because, as shown in figure 2, it marks the trough from which the boom of the 2000s begins. The results, however, are not sensitive to this choice. See below.

[7]The second-to-last row of table 1 shows that the null hypothesis of jointly zero country constants is strongly rejected in cases (a), (b) and (c), which supports the use of a panel regression with country fixed effects.

Table 1: Panel Regressions of the Gini Index on the Output Gap

Dependent variable: Gini index (market income)			
Variable	**(a) 1970-2013**	**(b) 1970-2000**	**(c) 2001-2013**
Intercept	50.67*** (0.24)	50.82*** (0.23)	50.29*** (0.43)
Output gap	-0.02 (0.04)	0.02 (0.03)	-0.24*** (0.05)
Adj. R^2 within	0.61	0.68	0.66
H_0: $\mu_i = 0$	F(13, 439)=54.44***	F(13, 273)=47.13***	F(13, 151)=24.25***
Obs (unbalanced)	454	288	166

Robust White cross-section standard errors in parentheses; *** denotes significance at the 1% level. Unbalanced panel regressions of the Gini index (in levels) on HP-filtered real GDP with country fixed effects. See the note to figure 1 for the list of 14 countries considered.

income), (b) changing the date the sample is split, as the results hold when the second subsample begins one and two years before and after that of the baseline case (1999, 2000, 2002, and 2003), and (c) the reduced number of observations from considering a balanced panel.[8]

3.2 Sectoral Composition of Economic Expansions

The boom of the 2000s was concentrated on service sectors, but this was not the case during the 1970s, the previous period of region-wide expansion.[9]

The top panel of figure 4 shows that the boom of the 2000s was concentrated on service sectors typically considered of nontradable nature:[10] *a*) construction; *b*) wholesale, retail trade, restaurants and hotels; *c*) transport, storage and communication; and *d*) other service

[8] An online technical appendix contains details on these robustness checks.

[9] Latin American growth was low and volatile during the so-called lost decade of the 1980s, in the aftermath of the region's debt crisis. The 1990s were a roller coaster, with spurts of growth drastically halted by the 1995 Tequila crisis and the effects of the 1997–98 East Asian and Russian crises. The 1960s is considered a period of strong growth in the region, but data on its sectoral composition is scarce. For accounts of the ups and downs in Latin America's growth of the 1980s and 1990s, see Kaminsky and Pereira (1996) and Loayza et al. (2004).

[10] See the note to figure 1 for a list of countries considered.

activities. Cumulative growth of value added in these four groupings was, on average, 51 percent, whereas total value added grew 45 percent. Manufacturing, typically considered a tradable sector, lagged behind, with growth of 30 percent, about three fifths the growth of service sectors.[11]

The bottom panel of figure 4 shows the 1970s expansion was more evenly spread across sectors. In particular, cumulative growth in manufacturing, at 81 percent, was similar to that of service sectors and total value added (with the exception of transport).

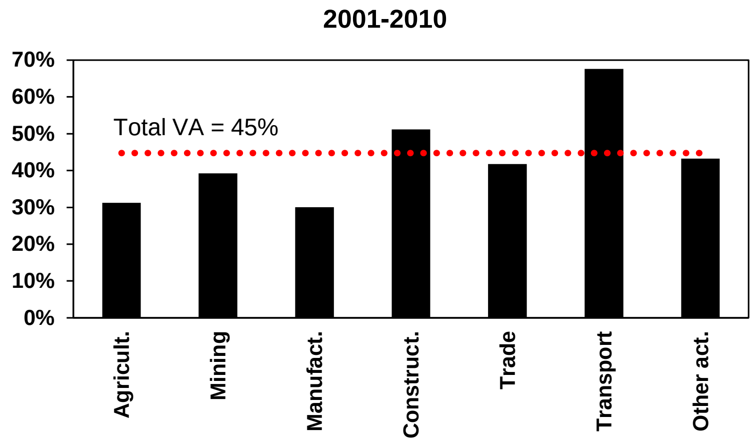
The results on cumulative sectoral growth shown in figure 4 have a potential drawback. There seems to be a declining secular trend in the share of manufacturing in value added and an increasing trend in the share of services, in Latin America as well as other advanced and emerging regions. Thus, figure 4 could be reflecting secular sectoral shifts rather than features of Latin America's expansions. To address this potential drawback, I follow Benigno, Converse, and Fornaro (2015) and detrend the sectoral shares of manufacturing and low-skilled services (the grouping that includes the first three service sectors) using the Hodrick-Prescott filter. Figure 5 shows the cyclical evolution of sectoral shares in value added as percent deviations from HP trends (mean and median values across 14 countries; sectoral shares computed from nominal data). The top two panels suggest that during the 2000s, there is a clear cyclical decline in the share of manufacturing and an expansion in the share of low-skilled services. The bottom two panels show no clear pattern during the 1970s, which confirms that the expansion in this period was more evenly spread across sectors.[12]

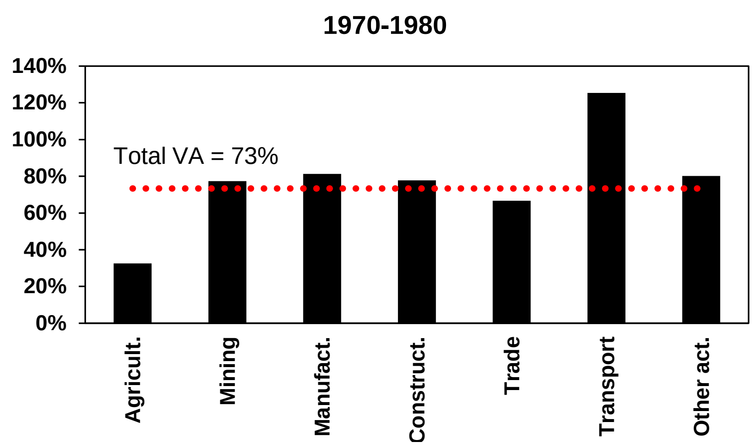
While there is no regional evidence on years of education or experience by sector, which would be natural proxies of skill intensity by sector, Mano and Castillo (2015) find that labor productivity, defined as real value added per worker, is substantially higher in the tradable

[11]The start and end dates for computing the boom of the 2000s, 2001–2010, are chosen because, as figure 2 shows, 2001 marks the trough from which the expansion begins, whereas 2010 marks the final year of growth of more than 5 percent, except for the brief interruption of 2009, the year in which the global financial crisis hit the region. The results, however, are not sensitive to the choice of dates. They are similar, for example, using 2000 and 2002 as starting dates. The technical appendix contains details on these robustness checks.

[12]A remaining limitation on the data that underlie figures 4 and 5 is that real values are not deflated by industry-level deflators, which would be ideal, but by the aggregate GDP deflator. Benigno et al. (2015) also face this limitation.

Figure 4: Cumulative Growth in Value Added During Latin American Expansions

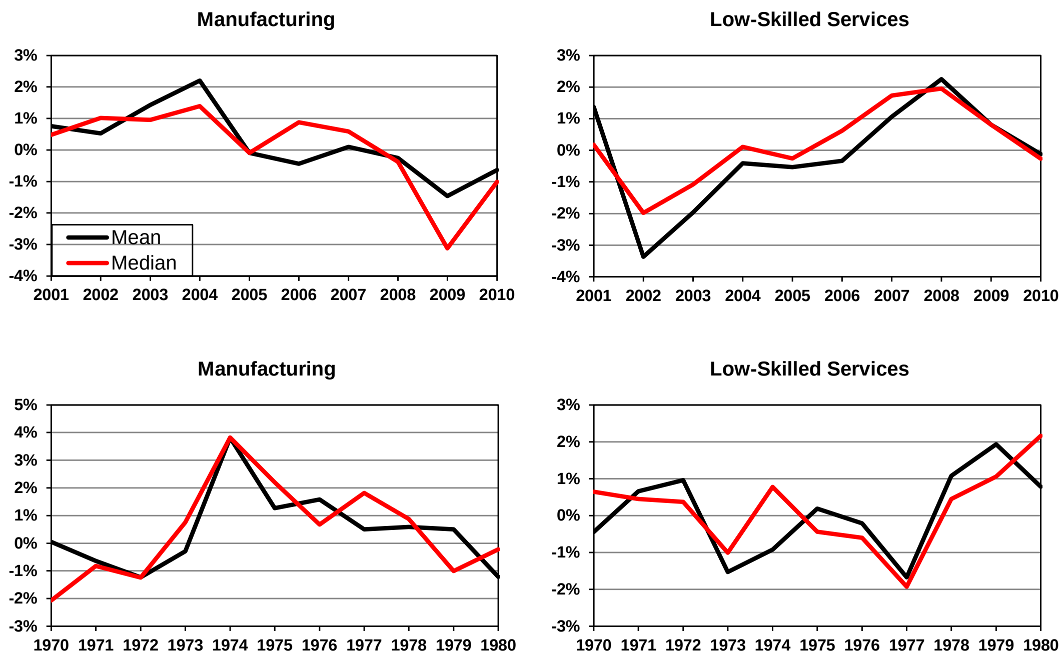




Median cumulative growth of value added across 14 countries. Cumulative growth is the percent difference between the final and initial year. The underlying data is expressed in constant 2005 prices and domestic currency. Sectoral groupings based on ISIC 3.0 classification of economic activities: Agriculture, hunting, forestry, fishing (ISIC A-B); Mining, manufacturing, utilities (ISIC C-E); Manufacturing (ISIC D); Construction (ISIC F); Wholesale, retail trade, restaurants and hotels (ISIC G-H); Transport, storage and communication (ISIC I); Other activities (ISIC J-P). See the note to figure 1 for the list of countries considered.

Source: Author's calculations based on data from the United Nations Statistics Division, March 2017.

Figure 5: Manufacturing and Services Over the Business Cycle



Mean and median evolution of sectoral shares in value added across 14 countries (see the note to figure 1 for the list of countries). Percent deviations from HP trend ($\lambda = 100$). Low-skilled services include (ISIC 3.0 codes in parenthesis): Construction (F); wholesale, retail trade, restaurants and hotels (G-H); transport, storage and communication (I). The underlying data is expressed in nominal terms.
Source: Author's calculations based on data from the United Nations Statistics Division, March 2017.

than in the nontradable sector, in Latin America and other regions. More productive workers are likely to be more skilled, so it is reasonable to believe that the nontradable sector is relatively more intensive in low-skilled labor.[13,14]

4 The DSGE Model

This section describes a model consistent with the evidence in the previous section that sheds light on the role of sectoral allocation on the evolution of the skill premium in Latin America. The model is a perfectly competitive small open economy populated by high-skilled and low-skilled households who supply the labor input used by representative firms that produce a tradable and a nontradable good. The nontradable sector is relatively intensive in low-skilled labor. Labor is freely mobile across the tradable and nontradable sectors. The driving forces of aggregate fluctuations in this economy are: (i) shocks to the price of a commodity endowment the government receives each period, and (ii) shocks to an international interest rate.

4.1 Households

There are high-skilled and low-skilled representative households. Both types of households have access to the international financial market, where they can buy and sell one-period risk-free foreign bonds. In what follows, individual (aggregate) variables are in lower (upper) case.

Households choose consumption and labor effort to maximize the expected present-

[13] Mano and Castillo (2015) find that productivity in the tradable sector is about 35–50 percent higher than in the nontradable sector in Latin America, depending on the classification of industries as traded/nontraded. These results consider data for Argentina, Brazil, Chile, and Mexico.

[14] It is possible, of course, that workers in the tradable sector are more productive because they have access to more and/or better capital while being less skilled than their counterparts in the nontradable sector. This is unlikely, however, in light of the evidence on *capital-skill complementarity*, the idea that capital equipment is more complementary to high-skilled than low-skilled labor. See Krusell et al. (2000) for an important application to the U.S. and Duffy, Papageorgiou, and Perez-Sebastian (2004) for evidence on a panel of developed and developing countries.

discounted value of lifetime utility:

$$\underset{c_{i,t};n_{i,t}}{\text{Max}} \quad \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j v(c_{i,t+j}; n_{i,t+j}), \tag{2}$$

for $i = \{H, L\}$, where H refers to high-skilled households and L to low-skilled households. $c_{i,t}$ is a consumption bundle of tradable and nontradable goods, $n_{i,t}$ is the number of hours worked by household i, and β is the discount factor.

I assume preferences are of the GHH form:[15]

$$v(c_{i,t}; n_{i,t}) = \frac{\left[c_{i,t} - \frac{1}{\omega}\left(n_{i,t}\right)^{\omega}\right]^{1-\sigma}}{1-\sigma},$$

where $\sigma > 0$ is the coefficient of relative risk aversion, and $\omega > 1$ governs the wage elasticity of labor supply, given by $({}^{1}/_{\omega-1})$. The consumption aggregator $c_{i,t}$ is a constant elasticity of substitution (CES) function that includes tradable and nontradable goods, denoted $c^x_{i,t}$ and $c^z_{i,t}$, respectively:

$$c_{i,t} = \left[\varphi^{\frac{1}{\chi}} \left(c^z_{i,t}\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} \left(c^x_{i,t}\right)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}. \tag{3}$$

The parameter $\varphi \in (0, 1)$ governs the share of nontradables in the consumption basket, and $\chi > 0$ is the constant elasticity of substitution between tradables and nontradables. The price of this basket is given by:

$$p_{i,t} = \left[\varphi \left(p_{z,t}\right)^{1-\chi} + (1-\varphi)\right]^{\frac{1}{1-\chi}}, \tag{4}$$

where $p_{z,t}$ is the relative price of the nontradable good. The tradable good is the numeraire, so its price is assumed to be equal to one and to obey the law of one price. The price index $p_{i,t}$, as well as the following demand schedules for tradable and nontradable goods, can be

[15]This preference specification is due to Greenwood, Hercowitz, and Huffman (1988). Correia, Neves, and Rebelo (1995) find this functional form is useful for real small open economy models to match features of aggregate fluctuations.

obtained by solving the problem of consumption maximization subject to a given level of expenditures:

$$c_{i,t}^{z} = \varphi \left(\frac{p_{z,t}}{p_{i,t}} \right)^{-\chi} c_{i,t}, \tag{5}$$

$$c_{i,t}^{x} = (1-\varphi) \left(\frac{1}{p_{i,t}} \right)^{-\chi} c_{i,t}. \tag{6}$$

In addition to purchasing tradable and nontradable goods, households receive a wage in exchange for labor services, are able to issue foreign one-period debt denominated in units of the tradable good, and pay lump-sum taxes. Therefore, the period-by-period budget constraint is given by:

$$p_{i,t}c_{i,t} + (1 + r_{i,t})d_{i,t} = w_{i,t}n_{i,t} + d_{i,t+1} - T_t, \tag{7}$$

where $d_{i,t}$ is the stock of foreign debt held by household i at the beginning of period t, which carries an interest rate $r_{i,t}$, $w_{i,t}$ is the real wage, and T_t denotes a lump-sum tax payment that is constant across households.

The interest rate at which household i in the small open economy borrows internationally is given by:

$$r_{i,t} = r + z_t^r + \psi \cdot (e^{\tilde{d_{i,t}} - d_i} - 1), \tag{8}$$

where r is a constant world interest rate and $z_t^r + \psi \cdot (e^{\tilde{d_{i,t}} - d_i} - 1)$ is a country spread over r. The first term of the spread, z_t^r, fluctuates exogenously and is common to all households, whereas the second term depends on the cross-sectional average of debt among households of type i, $\tilde{d_{i,t}}$, which each household takes as exogenous. As $\tilde{d_{i,t}}$ exceeds its steady state level d_i, the interest rate increases, with the parameter $\psi > 0$ governing the sensitivity of the interest rate to deviations of debt from steady state.[16]

[16] A debt-elastic interest rate premium is one of several ways to ensure foreign debt is stationary. See

The exogenous component of the interest rate spread evolves according to the following AR(1) process:

$$\ln(z_t^r) = (1 - \rho_{zr})\ln(\bar{z^r}) + \rho_{zr}\ln(z_{t-1}^r) + \epsilon_t^{zr}, \tag{9}$$

where $\bar{z^r}$ is the steady state level, $\rho_{zr} \in (-1, 1)$, and $\epsilon_t^{zr} \sim$ i.i.d.$(0, \sigma_{zr}^2)$.

Utility maximization results in standard optimality conditions:

$$(n_{i,t})^{\omega-1} = \frac{w_{i,t}}{p_{i,t}}, \tag{10}$$

$$\left[c_{i,t} - \frac{1}{\omega}(n_{i,t})^{\omega}\right]^{-\sigma} = \beta \mathbb{E}_t \left\{ \left[c_{i,t+1} - \frac{1}{\omega}(n_{i,t+1})^{\omega}\right]^{-\sigma} \frac{p_{i,t}}{p_{i,t+1}}(1 + r_{i,t+1}) \right\}. \tag{11}$$

Equation (10) is a labor supply schedule. Importantly, GHH preferences imply that labor supply is solely a function of the real wage, and in particular, there are no wealth effects on labor supply. Equation (11) is the household's intertemporal optimality condition.

4.2 Aggregation

Consumption aggregates and total private foreign debt are given by the following expressions:

$$C_t = c_{H,t} + c_{L,t}, \tag{12}$$

$$C_t^z = c_{H,t}^z + c_{L,t}^z, \tag{13}$$

$$C_t^x = c_{H,t}^x + c_{L,t}^x, \tag{14}$$

Schmitt-Grohé and Uribe (2003).

$$D_t = d_{H,t} + d_{L,t}. \tag{15}$$

4.3 Firms

Competitive representative firms in each sector choose high- and low-skilled labor to maximize profits. For simplicity, I abstract from capital accumulation. Both firms produce output according to a constant-returns-to-scale Cobb-Douglas technology. The government taxes income received by firms at a rate $\tau > 0$. Therefore, the tradable firm faces the following problem:

$$\underset{N^x_{H,t};N^x_{L,t}}{\text{Max}} \quad \Pi^x_t = (1-\tau)Y^x_t - w_{H,t}N^x_{H,t} - w_{L,t}N^x_{L,t}, \tag{16}$$

$$Y^x_t = A^x \left(N^x_{H,t}\right)^{\alpha_x} \left(N^x_{L,t}\right)^{1-\alpha_x}, \tag{17}$$

where Y^x_t is tradable output, A^x is a time-invariant total factor productivity index, $N^x_{H,t}$ is the quantity of high-skilled hours employed in the tradable sector, $N^x_{L,t}$ is the quantity of low-skilled hours, and α_x is the output elasticity of high-skilled labor in the tradable sector.[17]

Similarly, the firm that produces the nontradable good faces the following problem:

$$\underset{N^z_{H,t};N^z_{L,t}}{\text{Max}} \quad \Pi^z_t = (1-\tau)p_{z,t}Y^z_t - w_{H,t}N^z_{H,t} - w_{L,t}N^z_{L,t}, \tag{18}$$

$$Y^z_t = A^z \left(N^z_{H,t}\right)^{\alpha_z} \left(N^z_{L,t}\right)^{1-\alpha_z}. \tag{19}$$

Profit maximization by firms results in standard conditions for labor demand:

[17]The Cobb-Douglas production function (17) implies a unitary elasticity of substitution between high- and low-skilled labor. Duffy, Papageorgiou, and Perez-Sebastian (2004) offer estimates that range from 1.3 to 10 as a by-product of their empirical analysis of capital-skill complementarity in a panel of developed and developing countries.

$$w_{H,t} = (1-\tau)\alpha_x \frac{Y_t^x}{N_{H,t}^x}, \tag{20}$$

$$w_{L,t} = (1-\tau)(1-\alpha_x)\frac{Y_t^x}{N_{L,t}^x}, \tag{21}$$

$$w_{H,t} = (1-\tau)\alpha_z p_{z,t} \frac{Y_t^z}{N_{H,t}^z}, \tag{22}$$

$$w_{L,t} = (1-\tau)(1-\alpha_z) p_{z,t} \frac{Y_t^z}{N_{L,t}^z}. \tag{23}$$

I assume that the nontradable sector is relatively intensive in low-skilled labor, so that $\alpha_z < \alpha_x$. The assumption of a relatively high-skill-intensive tradable sector is somewhat related to the Dutch Disease literature, which often assumes the manufacturing tradable sector is "special" in the sense that it concentrates learning-by-doing, increasing returns to scale, spillover effects, or other positive externalities. See, for example, van Wijnbergen (1984), Lama and Medina (2012), and García-Cicco and Kawamura (2015).

4.4 Government

The government purchases tradable and nontradable goods, levies taxes on the income received by firms, collects lump-sum taxes from households, issues one-period risk-free foreign bonds denominated in units of the tradable good, and receives income from a constant endowment of a commodity that is completely exported at a price that fluctuates exogenously. Therefore, the government's budget constraint is given by:

$$p_t^G G_t + (1+r^G) D_t^G = \tau(Y_t^x + p_{z,t} Y_t^z) + T_t + D_{t+1}^G + p_t^{co} \bar{C}o. \tag{24}$$

G_t is a CES basket of tradable and nontradable goods purchased at price p_t^G, D_t^G is the stock of public foreign debt at the beginning of period t, for which the government pays interest rate $r^G = r + \bar{z^r}$, $\bar{Co}$ is the commodity endowment, and p_t^{co} is the commodity price, which evolves according to the following AR(1) proces:

$$p_t^{co} = (1 - \rho_{co})\ln(\bar{p^{co}}) + \rho_{co}\ln(p_{t-1}^{co}) + \epsilon_t^{co}, \tag{25}$$

where $\bar{p^{co}}$ is its steady state level, $\rho_{co} \in (-1, 1)$, and $\epsilon_t^{co} \sim$ i.i.d.$(0, \sigma_{co}^2)$.[18]

Regarding government purchases, I assume the degree of home bias and the elasticity of substitution between goods are the same as those for private purchases, so that:

$$G_t = \left[\varphi^{\frac{1}{\chi}} \left(G_t^z\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} \left(G_t^x\right)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}. \tag{26}$$

The price index p_t^G and the demand schedules G_t^z and G_t^x can be obtained by solving the problem of maximizing purchases subject to a given level of expenditure:

$$p_t^G = \left[\varphi \left(p_{z,t}\right)^{1-\chi} + (1-\varphi)\right]^{\frac{1}{1-\chi}}, \tag{27}$$

$$G_t^z = \varphi \left(\frac{p_{z,t}}{p_t^G}\right)^{-\chi} G_t, \tag{28}$$

$$G_t^x = (1-\varphi) \left(\frac{1}{p_t^G}\right)^{-\chi} G_t. \tag{29}$$

A fiscal policy rule consists of specifications for total government purchases and lump-sum taxes such that the government's intertemporal budget constraint is satisfied. Letting $Y_t \equiv Y_t^x + p_{z,t}Y_t^z + p_t^{co}\bar{Co}$ denote GDP at time t, government purchases are a function of last period's output gap—the deviation of GDP from its steady state level $\bar{Y}$:

$$G_t = \bar{G} + \phi_G \cdot (Y_{t-1} - \bar{Y}), \tag{30}$$

[18]It is common to assume the government receives income from the commodity sector, either because it owns companies that extract commodities or because it levies taxes on (mostly international) private companies. See, for example, Medina and Soto (2007), Berg et al. (2013), and Guerra-Salas (2014).

where $\bar{G}$ denotes the steady-state level of purchases, and the parameter ϕ_G governs the cyclical stance of fiscal policy.[19]

Lump-sum taxes adjust to stabilize public foreign debt around its steady state level $\bar{D^G}$:

$$T_t = \phi_T \cdot (D^G_{t-k} - \bar{D^G}), \tag{31}$$

where the parameter $\phi_T > 0$ determines the strength of the response, and k is the lag with which lump-sum taxes respond to deviations of debt from steady state.[20]

4.5 Market Clearing Conditions

High-skilled and low-skilled labor—the factors of production—are freely mobile across the tradable and nontradable sectors, so market clearing requires:

$$n_{H,t} = N^x_{H,t} + N^z_{H,t}, \tag{32}$$

$$n_{L,t} = N^x_{L,t} + N^z_{L,t}. \tag{33}$$

Nontradables cannot be exported or imported, so domestic demand must be satisfied by domestic supply:

$$Y^z_t = C^z_t + G^z_t. \tag{34}$$

Finally, the balance-of-payments identity holds for the small open economy:

[19]If $\phi_G > 0$ (< 0), government expenditure is procyclical (countercyclical). Lim and McNelis (2013) use a similar formulation for government purchases.

[20]Leeper, Walker, and Yang (2010) use similar debt-stabilization formulations for instruments such as transfers and tax rates.

$$\underbrace{-\left[\left(D^G_{t+1}-D^G_t\right)+\left(D_{t+1}-D_t\right)\right]}_{\text{capital account}}=\underbrace{\underbrace{\left[Y^x_t+p^{co}_t\bar{C}o-\left(C^x_t+G^x_t\right)\right]}_{\text{trade balance}}\underbrace{-\left[r_{H,t}d_{H,t}+r_{L,t}d_{L,t}+rD^G_t\right]}_{\text{net interest income}}}_{\text{current account}}, \tag{35}$$

4.6 Equilibrium

The competitive rational expectations equilibrium of the model is a set of sequences

$$\{Y^z_t; Y^x_t; C_t; C^z_t; C^x_t; c_{H,t}; c_{L,t}; c^z_{H,t}; c^x_{H,t}; c^z_{L,t}; c^x_{L,t}; N^z_{H,t}; N^x_{H,t}; N^z_{L,t}; N^x_{L,t};$$
$$n_{H,t}; n_{L,t}; G_t; G^z_t; G^x_t; T_t; D^G_t; d_{H,t}; d_{L,t}; r_{H,t}; r_{L,t}; z^r_t; p_{z,t}; p_{H,t}; p_{L,t}; p^G_t; p^{co}_t\}^{\infty}_{t=0},$$

such that the households' and firms' optimization problems are solved, and the markets for goods and factors of production clear, given the initial values $D^G_0, d_{H,0}, d_{L,0}$, and the exogenous sequences $\{\epsilon^{zr}_t, \epsilon^{co}_t\}^{\infty}_{t=0}$. The technical appendix lists the system of expectational difference equations that describe the competitive equilibrium.

I solve the model by linear approximation, and specifically, by taking a first-order Taylor series expansion around the model's deterministic steady state.

5 Calibration and Estimation

The model is calibrated to a representative Latin American country at quarterly frequency. A subset of parameters take values commonly found in the small open economy DSGE literature, others are calibrated so that the steady state of the model reproduces features of Latin American economies, and the parameters that govern the exogenous processes that drive aggregate fluctuations are estimated using Bayesian techniques.

Table 2 summarizes the calibration. The world interest rate r is set to 1 percent (on an annual basis) and the steady state interest rate spread $\bar{z^r}$ is set to 3.05 percent (annual basis), the mean value of the EMBI spread in Brazil, Chile, Colombia and Peru from 2000:Q1 to 2015:Q4. The coefficient of relative risk aversion $\sigma = 2$, as is common in the literature. Following Schmitt-Grohé and Uribe (2003), the parameter that governs the debt-elastic component of risk premium $\psi = 0.0007$; this small value ensures stationarity of the debt process without affecting the dynamics of the model. As in Pieschacón (2012), I set $\omega = 3$, which implies a wage elasticity of labor supply equal to 0.5. The elasticity of substitution between tradable and nontradable goods $\chi = 0.44$, as in Stockman and Tesar (1995). The parameters β and φ are obtained endogenously in the derivation of the model's steady state; see the appendix por details.

The model is calibrated so that its steady state reproduces features of five Latin American economies: Argentina, Brazil, Chile, Colombia, and Peru. These features, which appear in the last four rows of table 2, are median values, for the period 2000–2015, of the following ratios: commodity exports to GDP, private foreign debt to GDP, public foreign debt to GDP, and government spending to GDP.

As for the parameters related to fiscal policy, I assume lump-sum taxes are zero in the steady state and set the tax rate τ to 5.34 percent, so that the steady-state ratio of government purchases to GDP is 13 percent, and the ratio of public foreign debt to GDP is 15 percent. To calibrate ϕ_G, the parameter that governs the response of government purchases to the output gap, I run country-by-country regressions of total government expenditure on the output gap, and take the median value of the relevant coefficient, which is 1.18.[21,22] I set ϕ_T, the parameter that governs the reaction of lump-sum taxes to public debt, equal to 0.2, and assume lump-sum taxes react with a 1-quarter lag ($k = 1$) to deviations of public debt from steady state, but the results are not sensitive to this parameter; they are virtually

[21] Country coefficients are: 1.18 for Argentina, 0 (not significant) for Brazil, -0.71 for Chile, 1.38 for Colombia, and 1.18 for Peru . Regressions use quarterly data that begins in 2000:Q1 for all countries; the end date depends on data availability (Arg: 2013:Q3; Bra: 2014:Q4; Chi and Per: 2016:Q3; Col: 2016:Q2).

[22] A positive value for ϕ_G is consistent with the literature that finds fiscal policy is mainly procyclical in emerging countries, including Latin America. See, for example, Gavin and Perotti (1997), Frankel et al. (2013), and Ilzetzki and Végh (2008).

Table 2: Calibrated Parameters

Symbol	Value	Description
Parameters		
r	1	Annual world interest rate (%)
$\bar{z^R}$	3.05	Annual steady state EMBI spread (%)
β	0.9901	Discount factor
σ	2	Coefficient of relative risk aversion
ψ	0.0007	Risk premium parameter
ω	3	Governs wage elasticity of labor supply
χ	0.44	Elasticity of subst. tradables and nontradables
φ	0.44	Share of nontradables in CES baskets
α_x	0.79	Output elasticity of skilled labor (tradable)
α_z	0.25	Output elasticity of skilled labor (nontradable)
τ	5.34	Tax rate (%)
ϕ_G	1.18	Reaction of government purchases to output gap
ϕ_T	0.2	Reaction of lump-sum taxes public debt
k	1	Lag in reaction of lump-sum taxes (quarters)
Restrictions		
S_{CO}	7.98	Commodity exports-to-GDP ratio (%)
S_D	17.89	Private foreign debt-to-GDP ratio (%)
S_{Dg}	14.48	Public foreign debt-to-GDP ratio (%)
S_G	12.75	Government spending-to-GDP ratio (%)

identical under the assumption of an 8-quarter lag.

I calibrate the output elasticity of skilled labor in each sector, α_x and α_z, through an iterative procedure. These parameters take values from a grid until the skill premium in the steady state (${}^{w_H}/_{w_L}$) converges to 1.1, and the difference in average wages between the tradable and nontradable sectors converges to 5 percent.

The parameters that govern the exogenous processes that act as driving forces of fluctuations in the model economy are estimated using Bayesian techniques. For this purpose, quarterly data on log-deviations from HP trends for commodity prices and the EMBI spread are used as observable variables. I use the International Monetary Fund's commodity price index, and the average EMBI spread for four countries: Brazil, Chile, Colombia, and Peru, for the period 2000:Q1–2016:Q3.

Table 3 summarizes the results of the estimation. The priors are fairly loose and follow Fernández et al. (2015), with a Beta distribution with mean 0.5 and standard deviation 0.15 assumed for coefficients ρ_{co} and ρ_{zr}, and an Inverse Gamma distribution with mean 0.01 and infinite standard deviation for coefficients σ_{co} and σ_{zr}. The posterior densities are quite different from the loose priors, which means the data contain valuable information. The autocorrelation coefficients are somewhat persistent with values close to 0.7 (at the posterior mean), and the standard deviations of the shocks are quite high, with that of commodity prices taking a value of 9.3 percent, and that of the interest rate spread a value of 17.1 percent (about 50 basis points on an annual basis).

6 Analysis of the Model Economy

What are the effects of favorable commodity price and interest rate spread shocks on the model economy, and especially on the skill premium? In what follows, I offer a qualitative explanation of why these shocks generate a decline in the skill premium, and then quantify the fraction of the observed decline in the skill premium explained by the model.

Table 3: Estimated Parameters

Param.	Description	Dist.	Prior Mean	S.D.	Mode	S.D.	Posterior Mean	90% HPDI	
ρ_{co}	Autocorr. comm. p.	beta	0.5	0.15	0.6924	0.0691	0.6868	0.5744	0.8001
ρ_{zr}	Autocorr. spread	beta	0.5	0.15	0.6931	0.0697	0.6855	0.5681	0.8001
σ_{co}	S.D. comm. price sh.	invg	0.01	Inf	0.0911	0.0077	0.0933	0.0800	0.1062
σ_{zr}	S.D. spread shock	invg	0.01	Inf	0.1669	0.0142	0.1714	0.1470	0.1960

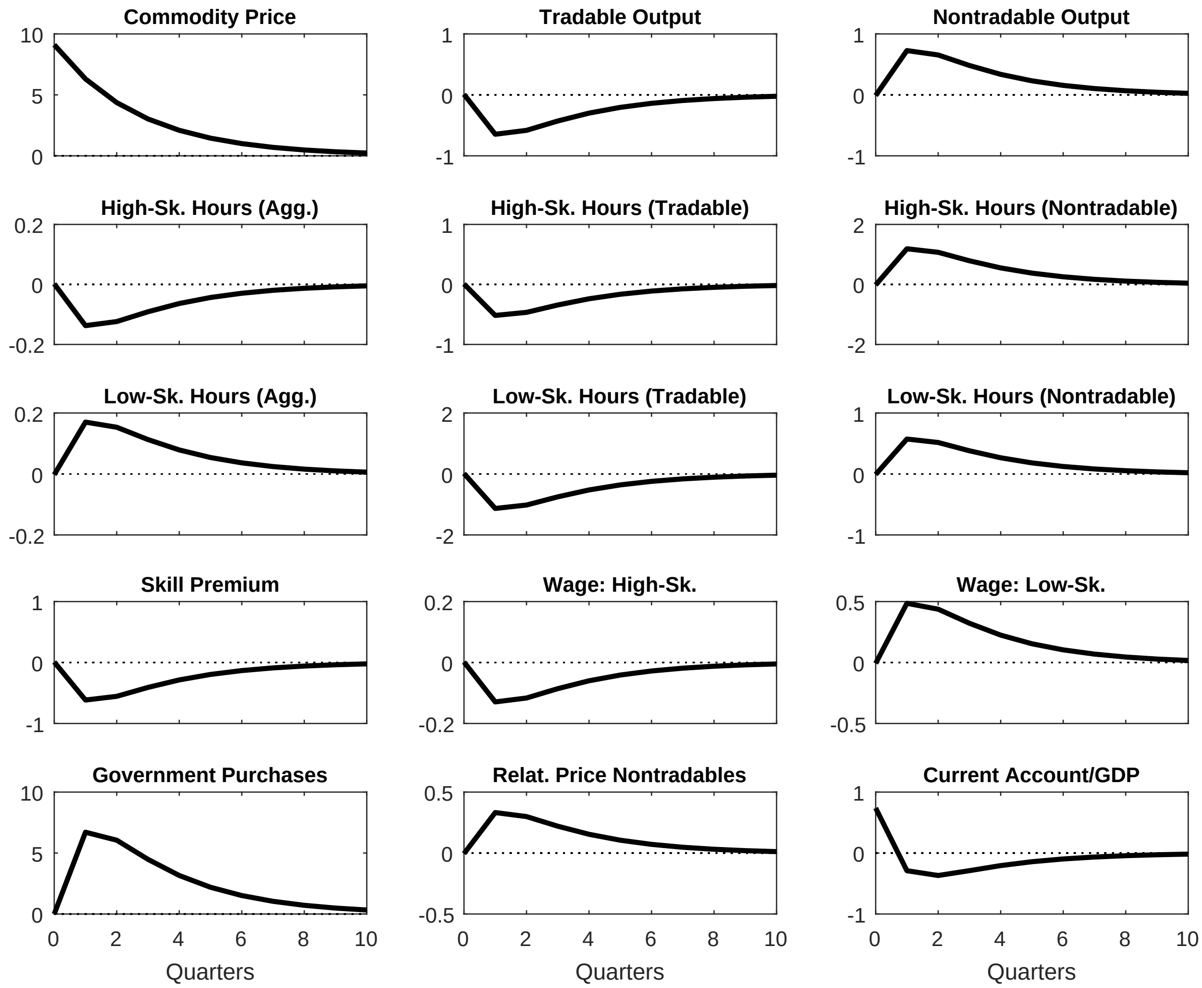
Results based on 200,000 draws from the posterior distribution using the Metropolis-Hastings (MH) algorithm, dropping the first 100,000 draws. The acceptance rate of the MH algorithm was approximately 25%. HPDI are the highest posterior density intervals. The computations were conducted using Dynare 4.4.3.

6.1 The Response of the Skill Premium to Favorable Shocks

Figures 6 and 9 show the dynamic effects of favorable one-standard-deviation shocks to commodity prices and interest rate spreads, respectively. Beginning with the former, note that the government is the sole recipient of commodity income, so a positive commodity price shock increases its revenue. Since it behaves procyclically, it expands its demand for tradable and nontradable goods (bottom-left panel of figure 6). Nontradable goods must be produced domestically, whereas tradables can be imported, so the increase in demand leads to an increase in the relative price of nontradables. The optimal response to the change in relative prices is a reallocation of labor input from the tradable to the nontradable sector (second and third rows), which results in an expansion of nontradable output and a contraction of tradable output (first row). Due to the different skill intensity of the tradable and nontradable sectors, this reallocation induces a decline in the skill premium. As the fourth row shows, the wage earned by high-skilled workers decreases while that of low-skilled workers increases. Finally, the current account improves on impact, since a higher commodity price increases the value of exports.

What is the intuition behind the fall in the skill premium? In a nutshell, the increase in demand for low-skilled labor relative to high-skilled labor triggered by the reallocation to the low-skill-intensive nontradable sector bids the low-skilled wage up and compresses

Figure 6: Impulse Responses to a Commodity Price Shock



Impulse responses to a one-standard-deviation commodity price shock. Percent deviations from steady state, except the current account-to-GDP ratio (bottom-right panel), which is the absolute deviation from steady state in percentage points.

Figure 7: Markets for High-Skilled and Low-Skilled Labor

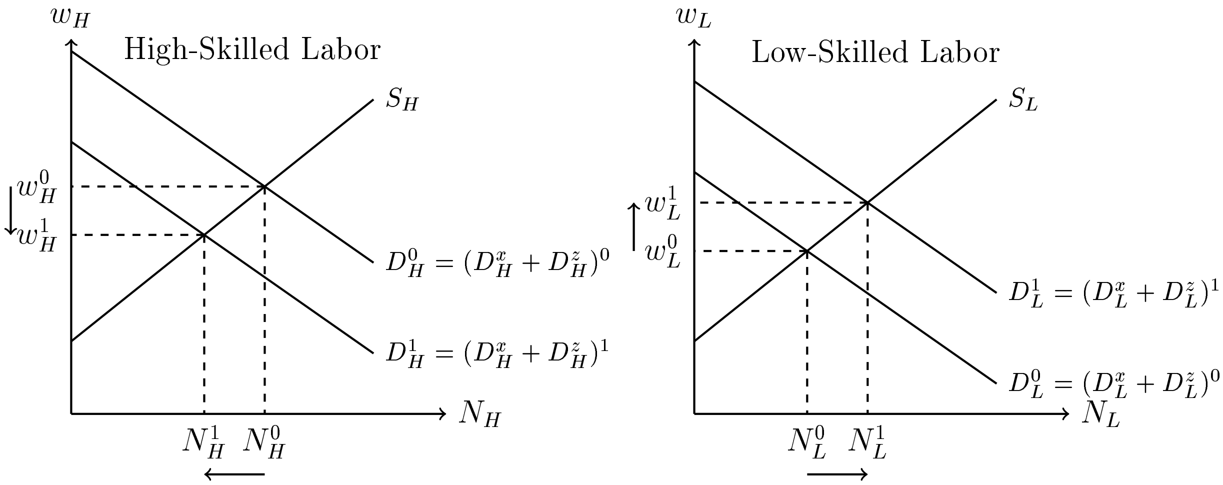


Illustration of the static effect of a favorable shock on the markets for high-skilled and low-skilled labor.

the premium. To provide intuition, figure 7 sketches the static effects of the shock on the markets for high- and low-skilled labor. Due to GHH preferences, labor supply depends only on the real wage, so equilibrium changes are the result of shifts in labor demand. The nontradable firm demands more of both high-skilled and low-skilled labor, taking wages as given. Conversely, the tradable firm demands less of both inputs. In the market for high-skilled labor (left panel of figure 7), demand by the nontradable firm increases, whereas demand by the tradable firm decreases, but the tradable sector is more intensive in high-skilled labor, so the overall effect is a decline in aggregate demand for high-skilled labor, pushing the equilibrium wage and hours worked down. In the market for low-skilled labor (right panel of figure 7), demand by the nontradable firm increases, whereas demand by the tradable firm decreases. But since the nontradable sector is more intensive in low-skilled labor, the overall effect is an increase in aggregate demand, which pushes the equilibrium wage and hours worked up.

The developments in both labor markets lead to a decline in the skill premium $\frac{w_H}{w_L}$. Since the premium is the relative price of high-skilled labor, both firms respond by increasing their ratio of high- to low-skilled labor. This narrative is illustrated in figure 8, which sketches isoquant and isocost curves for the tradable and nontradable firms.

Figure 8: Optimal Choice of Inputs

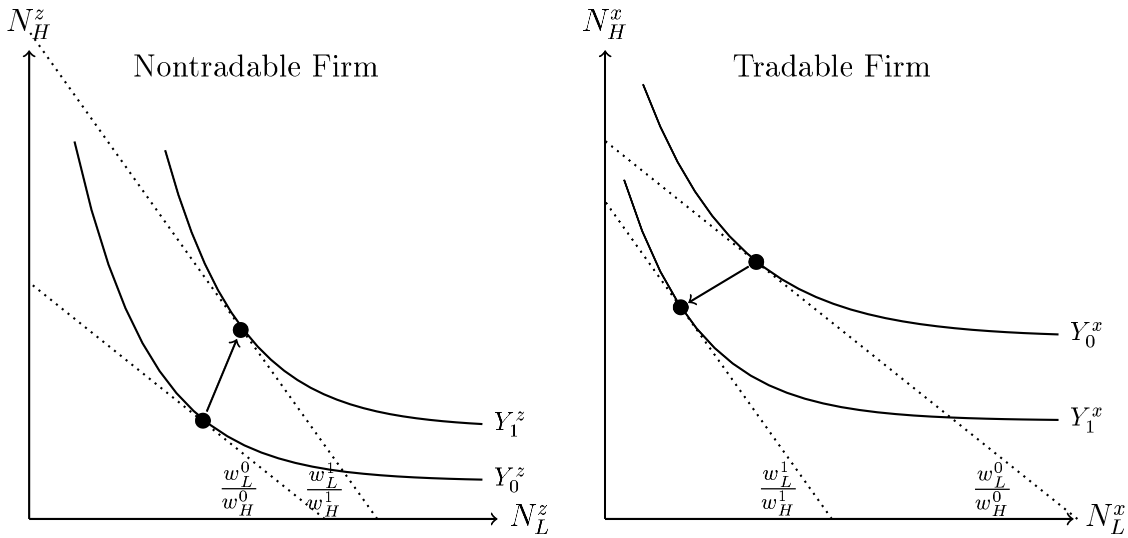
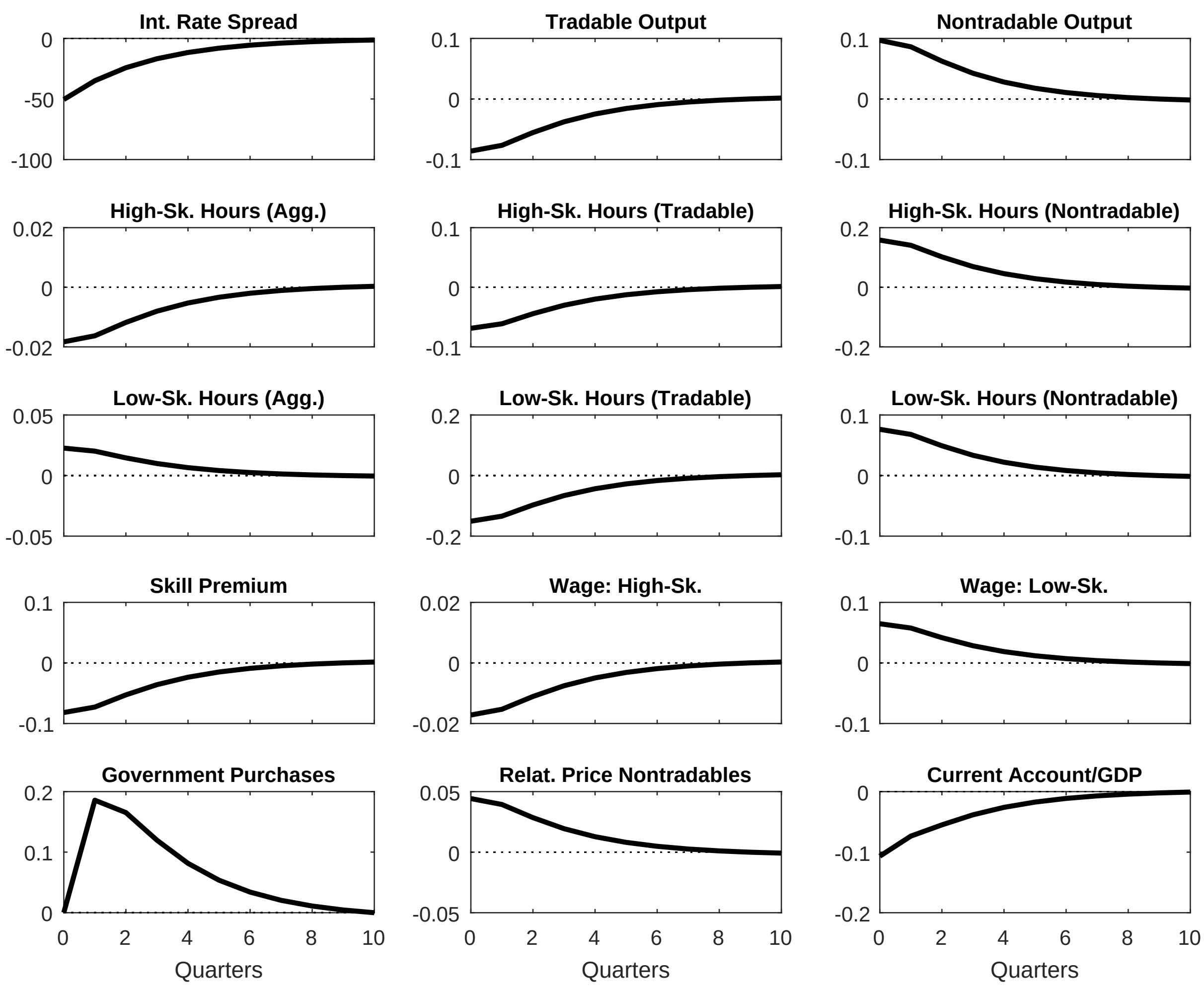


Illustration of the static effect of a favorable shock on firms' choice of inputs.

A favorable shock to the international interest rate spread produces similar qualitative effects on the model economy (figure 9). Facing lower interest rates, households substitute consumption intertemporally and increase their present demand for tradable and nontradable goods. This raises the relative price of nontradables, which cannot be imported, so the same mechanism leads to reallocation from the tradable to the nontradable sector and to a decline in the skill premium. The current account, however, deteriorates as a result of higher demand for imported goods (bottom-right panel).

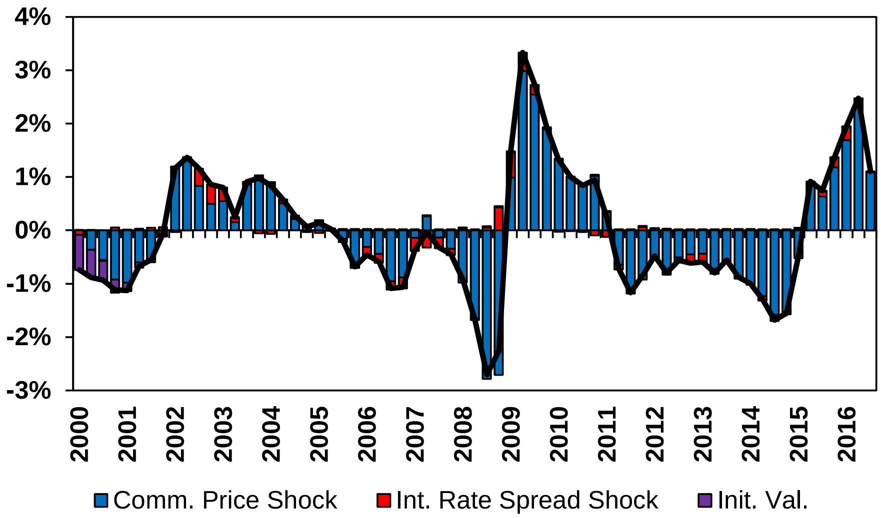
Quantitatively, the commodity price shock exerts a more powerful effect on the model economy than the interest rate spread shock. The response of the skill premium to a typical shock to commodity prices, at its trough, is nearly 10 times larger than its response to a typical shock to the spread. A preponderant role of commodity prices in the model economy is consistent with the findings in Fernández et al. (2015). The next subsection performs a quantitative analysis of the effect of favorable external shocks on the observed decline in Latin America's skill premium.

Figure 9: Impulse Responses to a Favorable Interest Rate Spread Shock



Impulse responses to a favorable one-standard-deviation shock to the interest rate spread. Percent deviations from steady state, except the interest rate spread (top-left panel), which is the absolute deviation from steady state, expressed in basis points on an annual basis, and the current account-to-GDP ratio (bottom-right panel), which is the absolute deviation from steady state in percentage points.

Figure 10: Skill Premium Inferred by the DSGE Model and Its Drivers



The line shows the skill premium (in percent deviations from steady state) inferred by the DSGE model when commodity prices and international interest rate spreads, the variables that drive aggregate fluctuations, are observable. Bars show the historical decomposition of structural shocks.

6.2 Quantitative Analysis

The evolution of commodity prices and international interest rate spreads, seen through the lens of the DSGE model, implies a sequence of shocks that act as driving forces of the model economy's business cycle.[23] The skill premium consistent with these structural shocks, for the period 2000:Q1–2016:Q3, is shown in figure 10 (as percent deviations from steady state). Throughout most of the sample, the skill premium exhibits a declining trajectory, with the exception of the early and latter portions, and the brief period, around 2009, in which the global financial crisis affected Latin America. The dynamic of the premium is predominantly explained by shocks to commodity prices; shocks to the interest rate spread push the premium in the same direction, but exert a much smaller force, as previously shown in the context of the impulse-response functions.

Ignoring the swings in 2009–2010, the model-inferred skill premium peaks in 2002:Q2 at

[23]The sequence of shocks is inferred by applying the Kalman smoother to the state-space representation of the DSGE model, with commodity prices and interest rate spreads (expressed as log deviations from HP trends) as observable variables. The sample is 2000:Q1–2016:Q3.

1.4 percent, and reaches a trough in 2014:Q3 at -1.8 percent, a decline of about 3 percentage points. In terms of the *level* of the premium, this dynamic implies a decline of 3 percent from peak to trough.[24]

How does the model-inferred decline in the skill premium compare to what is observed in the data? Using data from Montenegro and Patrinos (2014), it is possible to estimate the percent change in the skill premium from the early 2000s to 2012 (the last year with available data) for a sample of 18 Latin American countries.[25] Table 4 presents these results. It shows that the premium declined in 14 of the 18 countries, with a median decline of 15.5 percent (the mean decline is 13.8 percent). The model-inferred decline of 3 percent, therefore, would account for approximately a fifth of the fall in the skill premium observed in the data.

7 Conclusion

During the 2000s, income inequality declined substantially within most Latin American countries due to a delcine in the skill premium. This paper argues that part of this decline is driven by an economic expansion concentrated on low-skill-intensive nontradable sectors. Using a small open economy DSGE model calibrated and estimated to a typical Latin American country, I find that a favorable international environment, in particular high commodity prices, accounts for about a fifth of the decline in the skill premium observed in the data.

During the 2000s, income inequality was unusually sensitive to cyclical forces. I provide evidence that shows: (i) that inequality is acyclical prior to the 2000s but countercyclical thereafter, and (ii) that the boom of the 2000s was concentrated on service sectors, unlike the previous regional boom, that of the 1970s, which was more evenly spread across tradable and nontradable sectors.

The DSGE model abstracts from households' decisions to accumulate skills, i.e., from shifts in the skill composition of aggregate labor supply. In future research, it would be

[24]The skill premium is 1.1 at steady state, so it reaches 1.12 in 2002:Q2 and 1.08 in 2014:Q3: a 3 percent decline.

[25]This is suggested by work in progress due to Wim Naudé and Paula Nagler.

Table 4: Percent Change in the Skill Premium During the 2000s (Data)

Country	**Value**
Argentina	-25
Bolivia	-40
Brazil	-21
Chile	-11
Colombia	-19
Costa Rica	12
Dominican Republic	-15
Ecuador	-32
El Salvador	13
Guatemala	2
Honduras	4
Mexico	-13
Nicaragua	-23
Panama	-20
Paraguay	-26
Peru	-11
Uruguay	-16
Venezuela	-8
Median	-15.5
Mean	-13.8

Skill premium proxied by returns to tertiary education. Percent change taken, for most countries, between 2000 and 2012, due to data availability.
Source: Author's calculations based on data from Montenegro and Patrinos (2014) and work in progress due to Wim Naudé and Paula Nagler.

useful to augment the model with this feature in order to study the effects of labor supply and demand forces on the skill premium within a dynamic general equilibrium framework.

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