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Borders and Growth

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This paper presents a framework to understand and measure the effects of political borders on economic growth and per capita income levels. In our model, political integration between two countries results in a positive country size effect and a negative effect through reduced openness vis-à-vis the rest of the world. Additional effects stem from possible changes in other growth determinants, besides country size and openness, when countries are merged. We estimate the growth effects that would have resulted from the hypothetical removal of national borders between pairs of adjacent countries under various scenarios. We identify country pairs where political integration would have been mutually beneficial. We find that full political integration would have slightly reduced an average country's growth rate, while most countries would benefit from a more limited form of merger, involving higher economic integration with their neighbors.

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1. Introduction

Are existing national borders good or bad for economic growth? What would the growth rate of per capita income in Canada have been if its border with the United States had not existed, that is, if they had been a single country? What if Italy and France had merged? In brief, what is the effect of borders on economic performance?

National borders constitute barriers to economic exchange, and may therefore reduce gains from specialization and trade. Removing national borders allows the formation of larger domestic markets, which may have a positive effect on productivity and growth if market size matters for economic activity. However, as stressed in the regional integration literature, removing borders between regions while maintaining barriers with the rest of the world can bring about not only trade creation but also trade reduction. Moreover, national borders may shield some countries from slow-growing neighbors, and their removal might therefore reduce productivity and economic growth.

In order to estimate the effects of borders on growth one needs to answer three distinct but related questions:

(1) Is openness good for growth?

(2) Is a large market size good for growth?

(3) Does a country's openness depend on its size?

While there exist extensive literatures addressing each of those questions separately, there are very few theoretical and empirical analyses that examine effects of size and openness on growth *jointly*, treating openness as an endogenous function of size and other determinants. This paper argues that a simultaneous approach is essential. We will provide a unified exploration of these three important questions, and provide new quantitative answers.

We will then use our results to address whether existing national borders have been good or bad for growth. Specifically, we will ask a counterfactual question:

(4) Would existing countries have gained much from merging with their neighbors?

In a nutshell, our answers to the first three questions will be "*yes*". Our answer to the last one is "*it depends*".

In this paper we first present a simple theoretical framework accounting for the effects of openness and size on income and growth.[1] In our model, politically integrated economies can save on trading costs, generating a *market size effect* of political integration. However, trade openness responds endogenously to political integration. All other things being equal, in a political economy equilibrium, larger countries tend to choose higher trade barriers with respect to the rest of the world. Therefore, political integration, by increasing the size of countries and hence their barriers, also generates a *trade reduction effect*. Finally, political integration can induce changes in the other determinants of steady-state income levels, besides country size, an effect we call the *steady-state determination effect*. Within our stylized framework, we derive closed-form solutions for the relationship between steady-state income per capita, openness and country size. We also obtain a relationship between openness, barriers to trade and size. We then discuss necessary and sufficient conditions for a positive effect of political mergers on steady-state income per capita and on economic growth.

In the second part of this paper we provide an empirical methodology to evaluate the effect of national borders on economic growth. We estimate the effect

1 In the empirical literature "openness" is usually measured by trade/GDP. Conceptually, we can define a country as more "open" when it has lower barriers to trade. In our framework, a country's openness, measured by trade/GDP, is an endogenous function of trade barriers and other characteristics, including country size, while trade barriers also depend endogenously on country size. In this paper we refer to the volume of trade (trade to GDP ratio) as "openness" and to policy determined openness as "barriers".

of market size on economic growth in a cross-country context. In our specification, derived directly from the model, market size can be increased by two means: expanding the internal market or gaining greater access to foreign markets. Consistent with our theoretical framework, growth is affected both by openness and domestic size, which also interact with a negative sign (the effect of a larger domestic size is reduced at higher levels of openness, and the effect of openness is smaller for a larger domestic size). Openness itself is estimated—simultaneously with growth—as an endogenous variable which is affected by domestic size, among other determinants. We find robust evidence of positive effects of openness and size on growth, and of a negative effect of size on openness.

Together, these estimates allow us to quantify the economic effect of specific borders by creating hypothetical merged countries (for example the one that would result from the United States merging with Canada or France merging with Italy), and estimating what their growth rate would have been over the sample period. That is, we calculate the growth rate for each "hypothetical country" resulting from the merger of two actual countries. For example, the hypothetical country given by the merger of France and Switzerland is given by a size equal to the sum of the French and Swiss populations, an endogenously derived degree of openness as implied by the structural equation for a country with the size and geographical characteristics of "France plus Switzerland" (e.g. the country would not be landlocked), and other relevant steady-state determinants (e.g. human capital) as weighted averages of French and Swiss actual variables.[2] This empirical exercise corresponds exactly to our theoretical counterfactual. We present estimates of the market size effect, the trade reduction effect and the steady-state determination effect for all pairs of adjacent countries and proximate islands for which data are available (123 hypothetical pairwise mergers).[3] We identify cases where political integration would have been mutually beneficial to the merging countries, and discuss the conditions under which this occurs.

We find that the complete removal of political borders between neighbors (full integration) would *not* be growth-enhancing on average. In fact, on average it would bring about a (slight) *negative* net effect on growth: -0.112 percentage points of annual growth. In other words, the typical country would *lose* from pairwise political integration with a neighbor. Moreover, out of 123 hypothetical mergers, only 14 would bring about benefits for *both* countries involved in the merger. By contrast, integration of domestic markets in which each country remains politically independent would tend, on average, to increase growth performance across countries. In summary, while we find a few cases in which countries could benefit economically from full political integration with their neighbors, a more promising avenue for most countries would be to extend the size of their markets by lowering barriers to trade with their neighbors and the rest of the world, while maintaining their political independence.

2 Alternative scenarios to create "hypothetical countries" are discussed in Section 3.
3 The methodology can be easily extended to a case in which more than two countries consider integrating politically. We do not pursue such an extension in this paper.

This paper builds on and contributes to several related literatures. There exists a vast theoretical and empirical literature on the relationship between national borders and trade. Recent important contributions that directly document the effect of national borders on trade include McCallum (1995) and Helliwell (1998).[4] This literature suggests that removing national borders would substantially reduce barriers to interregional trade. A second, related body of work in the field of international trade is the extensive literature on the effects of regional integration on trade, efficiency and welfare. This literature has stressed how removing a specific political border can result in trade reduction vis-à-vis third countries. In particular, the classical theory of customs unions has pointed out the welfare losses from *trade diversion*.[5] More generally, the literature has studied the costs and benefits of regional integration in a second-best world in which integrated markets face barriers with the rest of the world.[6] A third, related body of work in the field of international trade, which is immediately relevant for our analysis, has focused on the endogenous formation of barriers to international trade.[7]

While we build on the theory and empirics of international trade, our approach in this paper is more closely linked to the growing macroeconomics literature on the relationship between openness, market size and growth. The relationship between openness and growth has been the focus of numerous studies, which include Sachs and Warner (1995), Frankel and Romer (1999), Rodríguez and Rodrik (2000), Wacziarg (2001), and Alcalá and Ciccone (2004) among others. In this literature the effect of openness on economic performance is usually studied without controlling for countries' domestic size. A second, smaller but growing literature has focused on the importance of market size for productivity and growth. In particular, our paper is most closely related to Alesina et al. (2000, henceforth ASW), who have stressed that (a) the effects of market size and openness on economic performance should be studied jointly, and (b) openness should have a larger effect for smaller countries, while domestic size should have a larger effect for closed countries.[8]

Our paper builds on the ASW framework. However, it addresses a different set of issues and, consequently, differs from the ASW framework in several key

4 This literature is not directly concerned with the effects of national borders on economic growth. In his important book on border effects in international trade, Helliwell (1998, chapter 6, p. 112) states that "assessing the possible growth implications of home preferences is not a job for a one-handed economist, nor for the faint of heart". We are not aware of research that tries to accomplish such measurement.

5 The classical reference is Viner (1950). For a textbook exposition see, for example, Vousden (1990), chapter 10.

6 For a survey of the regional-integration literature, see Baldwin and Venables (1995).

7 The political economy of trade barriers and protectionism is surveyed, for instance, by Rodrik (1995).

8 The effect of the extent of the domestic market on growth has also been investigated by Ades and Glaeser (1999). A recent confirmation of the Alesina–Spolaore–Wacziarg hypothesis on the relationship between size, openness and growth has been provided by Alcalá and Ciccone (2003).

respects. A central difference with the ASW framework is that we treat openness and barriers to trade as fully endogenous, and we consequently model and estimate growth and openness simultaneously. The ASW analysis focused on how exogenous changes in the level of trade barriers affect the number and size of nations in a world of endogenous borders. By contrast, our focus is on the effects of (counterfactual) *changes* in the configuration of borders on a country's level of openness and economic performance. Hence, in our empirical framework we jointly estimate the effects of market size and openness on growth and income levels *and* the relationship between openness and market size. Moreover, we use our estimates of the growth effects of market size and openness to construct the empirical analog to our theoretical counterfactuals, and to estimate the effects of specific borders on growth and income levels. Thus, we view this paper as providing a novel way to examine the relationship among market size, openness and growth, and to provide quantitative estimates of the economic effects of national borders.

This paper is structured as follows: Section 2 presents a model of economic growth based on scale effects, and analyzes the effect of borders on growth in this context. Section 3 describes our empirical methodology for estimating the border effect and discusses extensions to our basic strategy. Section 4 presents our empirical results, and Section 5 concludes.

2. A Model of Political Integration and Growth

This section presents a stylized model that links political borders, trade openness and productive activity. In this model, market size affects growth and income levels, and depends both on the degree of openness of the economy and on country size. Openness, measured by the ratio of trade to output, is itself endogenous, and responds to country size via endogenous barriers to trade. In our model, the effect of market size on productivity is *not* due to a technology with increasing returns, but to the benefits of variety: lower trading costs allow easier access to a set of intermediate inputs needed for the production of a homogeneous consumption good, using a production function with *constant* returns to scale.

The basic structure of the model is as follows: Countries are sets of regions. Each region uses its own immobile capital to produce a region-specific intermediate input. Intermediate inputs are traded both domestically (across regions within a country) and internationally (between regions that belong to different countries). International trade in intermediate inputs depends on the size distribution of countries and their barriers to trade. Trade barriers are themselves a function of political parameters and country size. The final good is used for local consumption and the accumulation of capital. The return to capital is also a function of the size distribution of countries and their international openness.

In the context of this model, we show that income per capita in steady-state and growth rates are increasing in country size and in international openness. The effect of size is larger for less open countries, while the effect of openness is larger for smaller countries. Finally, we describe how our model can be used to predict the effect of national borders on economic growth.

2.1. Assumptions of the Model

There is a continuum of regions, measured on the interval $[0, W]$. Time is continuous. The intertemporal utility function in each region i is given by:

$$U_i = \int_0^\infty \ln c_i(t) e^{-\rho t} dt, \tag{1}$$

where $c_i(t)$ denotes consumption at time t by the representative household living in region i, and $\rho > 0$.[9] At time t region i's capital and labor are denoted, respectively, by $K_i(t)$ and $L_i(t)$. Both inputs are supplied inelastically and are not mobile across regions. Each region i produces a specific intermediate input $X_i(t)$ using the region-specific capital according to the following linear production function:

$$X_i(t) = K_i(t). \tag{2}$$

There exists a unique final good. Each region i produces $y_i(t)$ units of the final good, using tradeable intermediate goods from its own region and other regions, according to the production function:

$$y_i(t) = \left(\int_0^W x_{ji}^{\alpha}(t) dj\right) L_i^{1-\alpha}(t) \tag{3}$$

with $0 < \alpha < 1$. $x_{ji}(t)$ denotes the amount of intermediate input j used in region i at time t.

Regions are divided into N countries. Country 1 includes all regions in the interval $[0, S_1)$, country 2 includes all regions in the interval $[S_1, S_1 + S_2)$, country n includes all regions in the interval $[S_{n-1}, S_{n-1} + S_n)$, and country N includes all regions in the interval $[S_{N-1}, S_{N-1} + S_N]$. Each region inelastically supplies one unit of labor (i.e., $L_i(t) = 1$ for every i at every t.). Hence, the size of country n (measured by total labor) is equal to S_n, where $n = 1, 2, \ldots, N$.

Intermediate inputs can be traded across regions that belong to the same country at no cost (i.e., we assume no internal barriers to trade). By contrast, if one unit of an intermediate good j that belongs to country a is shipped to a region that belongs to a different country (say, country b), only $(1 - \xi_a - \xi_b)$ units of the intermediate good will arrive, where $0 < \xi_a + \xi_b \leq 1$. Hence, the levels of ξ_n's measure barriers to trade across national borders. Let $f_{ii'}$ denote the units of intermediate input i produced in region i of country a and shipped to region i' in country b. Because of barriers to trade, the quantity of intermediate input i actually used in production in region i' is given by $x_{ii'} = (1 - \xi_a - \xi_b) f_{ii'}$.

9 As usual, the results generalize to any standard CRRA utility function $(c_i(t)^{1-\sigma} - 1)/(1 - \sigma)$ with $\sigma > 0$.

2.2. *Equilibrium*

Intermediate inputs are sold in perfectly competitive markets. In equilibrium, each unit of each inputs will be sold at a price equal to its marginal product. All regions that belong to the same country will use identical levels of a given input. Hence, we can let x_{in} denote the amount of input i actually used in each region of country n, while f_{in} will denote the quantity of input i purchased by a region in country n. Let $P_i(t)$ denote the market price of intermediate input i, where region i belongs to country a. Therefore, for every input i belonging to a country a and for every country $n \neq a$ we must have:

$$P_i(t) = \alpha x_{ia}^{\alpha-1}(t) = \alpha(1-\xi_a-\xi_n)^{\alpha} f_{in}^{\alpha-1}(t). \tag{4}$$

By using equation (4) and the resource constraint, we can obtain the equilibrium price of each input i produced in country a, as shown in Appendix 1:

$$P_i(t) = \alpha \left[S_a + \sum_{n \neq a} S_n (1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}} \right]^{1-\alpha} K_i(t)^{\alpha-1}. \tag{5}$$

Households' net assets in region i are identical to the stock of region-specific capital $K_i(t)$. Since each unit of capital yields one unit of intermediate input i, the net return to capital is equal to the market price of intermediate input $P_i(t)$ (for simplicity, we assume no depreciation). From standard intertemporal optimization we have the following Euler equation for consumption in region i belonging to country a:

$$\frac{dc_{it}}{dt}\frac{1}{c_{it}} = P_i(t) - \rho = \alpha \left[S_a + \sum_{n \neq a} S_n (1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}} \right]^{1-\alpha} K_i(t)^{\alpha-1} - \rho. \tag{6}$$

As usual in a standard Ramsey model, the steady-state level of capital in each region i belonging to country a is obtained as the solution of the above equation at $\frac{dc_{it}}{dt}\frac{1}{c_{it}} = 0$:[10]

$$K_i^{ss} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \left[S_a + \sum_{n \neq a} S_n (1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}} \right]. \tag{7}$$

The steady-state level of output per capita in a region i of a country of size S_a is given by:[11]

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10 For example, see Barro and Sala-i-Martin (1995), chapter 2.

11 The derivation of Equation (8) is in the Appendix. A similar relationship between income per capita, barriers to trade, and size distribution of countries would hold in a static setting in which there is a nonaccumulable region-specific input and all regions are equally endowed with the same quantitities of it. The details of the derivation are available upon request. We are grateful to an anonymous referee for this observation.

$$y_i^{ss} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left[S_a + \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}} \right]. \tag{8}$$

Our model has standard neoclassical implications as far as the growth rate is concerned. In particular, at each point in time the growth rate of income per capita is positively related to steady-state income per capita and negatively related to the current (initial) level of income:[12]

$$\frac{d \ln y_n(t)}{dt} = f(y_n^{ss}, y_{n,t-\tau}) \tag{9}$$

with

$$\frac{\partial f}{\partial y_n^{ss}} > 0, \quad \frac{\partial f}{\partial y_{n,t-\tau}} < 0. \tag{10}$$

Therefore, the effects of size, openness or other variables on the level of income per capita also translate into effects on the growth rate in the transition to the steady-state. Thus, in this theoretical section we will focus our analysis on steady-state income. Implications for growth will be studied in the empirical section.

2.3. Steady-state Income, Country Size, and International Openness

We are now ready to derive the relationships between steady-state income per capita, country size, barriers to trade, and international openness. In what follows we will consider these relationships under the simplifying assumption that barriers to international trade (the parameters $\xi' s$ in the above equations) are exogenous.[13] Equation (8) implies the following:

Proposition 1 *Income per capita in steady-state is increasing in country size* (*for given barriers to international trade*) *and decreasing in barriers to trade* (*for given country size*). *The positive effect of size is higher the higher are the barriers to international trade* (*i.e., size matters more for less open countries*).

Derivation of Proposition 1. Equation (8) implies that the derivative of income per capita in steady state for a region i in country a with respect to country a's barriers is:

$$\frac{\partial y_i^{ss}}{\partial \xi_a} = -\frac{\alpha}{1-\alpha} \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha} - 1} < 0. \tag{11}$$

This shows that income per capita is decreasing in barriers to trade, for given country size. Conversely, if country size is increased by ∂S_a, while the size of

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12 For a derivation of these standard results see, for example, Barro and Sala-i-Martin (1995).

13 In Section 2.4 we will extend the analysis to allow for endogenous barriers to trade.

each other country is decreased by $\sum_{n\neq a}\partial S_n = -\partial S_a$, while all barriers remain unchanged, we have:[14]

$$\frac{\partial y_i^{ss}}{\partial S_a} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}\left[1 - \frac{1}{N-1}\sum_{n\neq a}(1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}}\right] \geq 0. \tag{12}$$

Notice that the effect of country size is strictly positive if and only if there are barriers to international trade—i.e., at least some $\xi's$ are positive. In the case of complete free trade everywhere (all $\xi's$ equal to zero), the derivative in equation (12) becomes zero.[15] That is, country size matters in a world of barriers to trade, while it would not matter if there were no barriers to trade across political borders (complete economic integration). By the same token, an *increase* in the barriers to trade would make the effect of country size on income *bigger*: country size matters more for countries with higher barriers to trade (i.e., for less open countries):

$$\frac{\partial^2 y_i^{ss}}{\partial S_a \partial \xi_a} = \frac{\alpha}{1-\alpha}\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}\frac{1}{N-1}\sum_{n\neq a}(1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}-1} \geq 0. \tag{13}$$

In summary, we have shown that income per capita is increasing in country size, decreasing in barriers to trade, and that the effects of size is larger for countries with higher barriers to trade. These relationships have been derived in terms of barriers to international trade. However, it might be empirically difficult to observe and measure barriers to trade directly: in our theory these barriers include not only formal trade barriers (tariffs, nontariff barriers) but also differences in legal systems and political barriers restricting the flow of goods, which are all hard to measure.

A standard way of assessing a country's openness to international trade is in terms of its ratio of exports plus imports to output. Following standard terminology, we will refer to this ratio as "openness". Within our theoretical framework, we can easily show that in steady-state, "openness" (which is obviously endogenous) bears a monotonic relationship with barriers to trade. Specifically, let O_a denote the exports to output ratio.[16] Each region in country a will use x_{ia}^{ss} units of inputs locally, and will sell an equal amount x_{ia}^{ss} to each of the other $S_a - 1$

14 When studying the comparative statics of country size, it is important to make sure that an increase in a country's size is accompanied by a corresponding reduction in the size of one or more of the remaining countries. An increase in the size of a given country without a corresponding reduction in other countries' sizes would mix two distinct effects: a "country size" effect, and an effect stemming from the overall "expansion of the world market" (i.e., from a bigger parameter W). For simplicity and without loss of generality, in our derivation we assume that all remaining $N-1$ countries experience an equal reduction in size, that is, $\partial S_n = -\frac{\partial S_a}{N-1}$ for all $n \neq a$.

15 It is immediate to check that: $\frac{dy_i^{ss}}{dS_a} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}[1 - \frac{1}{N-1}(N-1)] = 0.$

16 In this model we abstract from international borrowing and lending—hence exports are always equal to imports in equilibrium. Therefore, measuring openness as exports/output is identical, up to a scalar multiplication, to measuring openness as (exports + imports)/output.

regions belonging to country a. Hence, total exports of input i will be given by $K_i^{ss} - S_a x_{ia}^{ss}$. Since all regions in country a export the same amount, total exports in country a are given by $(K_i^{ss} - S_a x_{ia}^{ss})S_a$. Country a's total output is given by $y_i^{ss} S_a$. Therefore, the exports to output ratio O_a in steady-state is given as follows:

$$O_a^{ss} = \frac{(K_i^{ss} - S_a x_{ia}^{ss})S_a}{y_i^{ss} S_a}. \tag{14}$$

By using the expression for x_{ia} derived in Appendix 1 and equations (7) and (8), we can write the equilibrium steady-state level of openness as:

$$O_a^{ss} = \left(\frac{\rho}{\alpha}\right)^{\alpha} \frac{\sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}}{S_a + \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}} \tag{15}$$

which implies that O_a^{ss} is decreasing in ξ_a:

Proposition 2a *Openness in steady-state is inversely related to a country's barriers to trade.*

Formally:

$$\frac{dO_a^{ss}}{d\xi_a} = -\frac{\alpha}{1-\alpha}\left(\frac{\rho}{\alpha}\right)^{\alpha} \frac{S_a \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}-1}}{\left[S_a + \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}\right]^2} \leq 0 \tag{16}$$

Hence, all other things being equal, higher barriers to international trade are associated with higher openness.

As we will see in the empirical section, the data are consistent with the main insights from the above analysis, that is, (a) country size and openness are positively related to higher income per capita in steady-state (and hence higher growth in the transition to the steady-state), and (b) other things equal, the effect of size is larger for countries with higher barriers to trade (and, hence, lower openness), while the effect of higher barriers and lower openness is bigger for smaller countries.

When studying these relationships both theoretically and empirically, it is important to keep in mind that openness is an endogenous variable. In particular, there are two conceptually distinct reasons why openness is endogenously related to country size. First, even for given barriers to international trade, *openness is a function of country size*, as it is immediate to verify from equation (15). All other things equal, an increase in country size tends to be associated with lower openness. Formally, we have:[17]

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17 Again, we assume that the size of all other countries is equally reduced, that is, $dS_n = -dS_a/(N-1)$ for all $n \neq a$.

$$\frac{dO_a^{ss}}{dS_a} = -\left(\frac{\rho}{\alpha}\right)^{\alpha} \frac{\frac{S_a}{N-1}\sum_{n\neq a}(1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}} + \sum_{n\neq a} S_n(1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}}}{\left[S_a + \sum_{n\neq a} S_n(1-\xi_a-\xi_n)^{\frac{\alpha}{1-\alpha}}\right]^2} \leq 0, \qquad (17)$$

which implies:

Proposition 2b *Openness in steady-state is inversely related to a country's size, for given barriers to trade.*

Second, as we will see below, barriers to trade can also be modeled as an endogenous function of size. This introduces an additional channel through which size can affect openness negatively. These endogenous links between openness and size will be taken into account in our empirical analysis of the effects of country size and openness on income and growth—that is, openness will be explicitly modeled as a function of country size and other determinants.

2.4. Endogenous Barriers to Trade

So far we have considered barriers to trade as given. We will now extend the analysis to allow for an endogenous determination of barriers. Specifically, we will assume that, for each country n barriers are given as follows:

$$\xi_n(t) = \frac{\xi}{2} - \lambda_n(t), \qquad (18)$$

where $\lambda_n(t)$ is a variable controlled by the government of country n. A higher $\lambda_n(t)$ means lower barriers.

It is reasonable to assume that lower trade barriers may entail political and administrative costs. We capture the costs of lower barriers in a stylized manner, by assuming a convex cost $(\phi_n[\lambda_n(t)]^2)/2$.[18] On the other hand, trade barriers may bring about political benefits (say, rents) to a country's policy-makers. We capture these rents as a simple, linear function of the barriers. Specifically, we assume that the government of country n will choose $\lambda_n(t)$ in order to maximize the following objective function:[19]

$$\psi_n\xi_n(t) + (1-\psi_n)c_n(t) - \frac{\phi_n}{2}[\lambda_n(t)]^2 \qquad (19)$$

18 This quadratic specification is assumed for convenience in order to obtain a closed-form solution below. The assumption is not necessary for an interior solution, and could be generalized to $\phi_n[\lambda_n(t)]^{\zeta}$ with $\zeta \geq 0$. For example, an interior solution exists for the case of costs independent of λ ($\zeta = 0$) and for the case of costs linear in λ ($\zeta = 1$), when $\alpha < 1/2$.

19 For simplicity we assume that policy-makers have measure zero in the economy, and therefore their rents and costs do not affect per capita consumption, capital accumulation and production directly, but only through policy decisions.

ψ_n is the weight given to the "political" benefits or rents associated with barriers to trade, while $1-\psi_n$ is the weight given to the consumption level of the representative consumer at time t.[20]

In general, at each point in time barriers are a function of the political parameters ψ_n and ϕ_n and of the determinants of the equilibrium consumption path. In particular, we focus on the steady-state level of barriers ξ_n^{ss}, which is defined as the solution of the following:

$$\max_{\lambda_n}\left\{\psi_n\xi_n+(1-\psi_n)\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}c_n^{ss}-\frac{\phi_n}{2}\lambda_n^2\right\}. \tag{20}$$

Since steady-state consumption is equal to steady-state income in our model, we can substitute c_n^{ss} in equation (20) with y_n^{ss} from equation (8). Hence the steady-state level of λ_a^{ss} for a country of size S_a is given by

$$\lambda_a^{ss}=\arg\max_{\lambda_a}\left\{\psi_a\left[\frac{\xi}{2}-\lambda_a\right]+(1-\psi_a)\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}\right.$$
$$\left.\times\left[S_a+\sum_{n\neq a}S_n\left(1-\frac{\xi}{2}+\lambda_a-\xi_n\right)^{\frac{\alpha}{1-\alpha}}\right]-\frac{\phi_a}{2}\lambda_a^2\right\}. \tag{21}$$

For each country $a=1,2,\ldots,N$, the first-order condition for λ_a^* is given as follows:

$$-\psi_a+(1-\psi_a)\frac{\alpha}{1-\alpha}\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}\sum_{n\neq a}S_n(1-\frac{\xi}{2}+\lambda_a^{ss}-\xi_n)^{\frac{2\alpha-1}{1-\alpha}}]-\phi_a\lambda_a^{ss}=0. \tag{22}$$

In general, the equilibrium level of barriers reduction in each country is a function of the size distribution of all countries.[21] Other things equal, smaller countries tend to have lower barriers. For example, in a world of two countries ($W=S_a+S_b$) with identical political parameters ($\psi_a=\psi_b=\psi$ and $\phi_a=\phi_b=\phi$) we have:[22]

$$\frac{d\lambda_a^{ss}}{dS_a}=-\frac{1-\psi}{\phi}\frac{\alpha}{1-\alpha}\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}(1-\xi+\lambda_a^{ss}+\lambda_b^{ss})^{\frac{2\alpha-1}{1-\alpha}}<0. \tag{23}$$

20 A specification in which policy-makers attach weight both to their rents (contributions from lobbies) and to their citizens' welfare is provided, for instance, in Grossman and Helpman's (1994) classic analysis of protectionism. For a survey of this extensive literature see, for example, Rodrik (1995). In our theory we do not model a private demand for protection explicitly, but just assume that the government's rents are a function of barriers. Our main results would go through even if $\psi_n=0$. More generally, we will assume $0\leq\psi_n<1$.

21 We assume that each country will choose its barriers taking other countries' barriers as given. That is, in each first-order condition, other countries' barriers will be taken as given at their equilibrium level (i.e., $\xi_n^{ss}=\frac{\xi}{2}-\lambda_n^{ss}$ for all $n\neq a$). By contrast, joint maximization of world welfare would imply lower barriers.

22 The result can be generalized to the case of three or more countries.

A simple closed-form solution can be obtained for the case $\alpha = 1/2$. Then the degree of barrier reduction λ_a^* that maximizes output per capita minus barriers reduction costs for a country of size S_a is:

$$\lambda_a^{ss} = \frac{(1-\psi_a)(W-S_a)}{2\phi_a \rho} - \frac{\psi_a}{\phi_a} \tag{24}$$

which, again, implies a negative relationship between barrier reduction and size:[23]

$$\frac{d\lambda_a^{ss}}{dS_a} = -\frac{1-\psi_a}{2\phi_a \rho} < 0. \tag{25}$$

Hence, we have the following:

Proposition 3 *All other things equal, larger countries will have less open trade policies—that is, they will choose lower λ_a^{ss}—and, consequently, higher barriers ξ_a^{ss}.*

Countries with lower costs of reduction (ϕ_a), lower weight on political rents (ψ_a) or a lower discount rates (ρ) will be more open (that is, will have a higher λ_a). Why do larger countries have higher barriers, and smaller countries lower barriers, all other things being equal? The result stems directly from the fact that in larger countries higher barriers are not as costly as in smaller countries in terms of income per capita and consumption per capita, because in larger countries more intermediate inputs are purchased domestically—that is, from other regions within the country. In contrast, smaller countries need to purchase more intermediate goods abroad, and hence are more heavily hurt by international barriers. As a consequence, in smaller countries politicians who attach some weight to national income per capita and national consumption will choose a lower level of protectionism, while in larger countries they will be able to "afford" more protectionism. These results hold even though we assumed that political rents from barriers are independent of the level of domestic production. If we were also to assume that political rents are increasing in the size of domestic production, the relationship between barriers and country size would be strengthened. Finally, an interesting issue, which we do not pursue in this analysis, is the possibility that barriers between countries may depend on incompatibilities in administrative procedures and legal frameworks. In this case, the costs of removing the barriers would include the costs to coordinate and harmonize procedures across countries.[24]

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23 It is immediate to check that (23) reduces to (25) for $\alpha = 1/2$.

24 These costs could be modeled either directly (as coordination costs), or by assuming that each country adopts administrative and legal procedures of a given type, and that changing type implies political costs. This is in analogy to models in which people in different locations have different preferences over the type of public services provided by the government, and moving away from one's favored type of government implies heterogeneity costs (see Alesina and Spolaore, 2003).

2.5. *Political Mergers*

Let us now consider a merger between country a (of size S_a) and country b (of size S_b). To keep things simple we will assume $\alpha = 1/2$ and $\psi_a = \psi_b = \psi$ and $\phi_a = \phi_b = \phi$. The steady-state levels of income per capita in country a is:

$$y_a^{ss} = \left(\frac{1}{2\rho}\right)\left[S_a + \sum_{n \neq a} S_n (1 - \xi_a^{ss} - \xi_n^{ss})\right]. \tag{26}$$

The steady-state income per capita in the new country of size $S_m = S_a + S_b$ will be:

$$y_m^{ss} = \left(\frac{1}{2\rho}\right)\left[S_m + \sum_{n \neq m} S_n (1 - \xi_m^{ss} - \xi_n^{ss})\right]. \tag{27}$$

The net change in steady-state income for country a will be given by

$$y_m^{ss} - y_a^{ss} = \left(\frac{1}{2\rho}\right)[S_b(\xi_a^{ss} + \xi_b^{ss}) - (W - S_a - S_b)(\xi_m^{ss} - \xi_a^{ss})]. \tag{28}$$

In equation (28), the first term, $(1/2\rho)\, S_b(\xi_a^{ss} + \xi_b^{ss})$, measures the direct positive scale effect of the merger, which we call the *market size effect*. It is evaluated at the level of trade barriers prevailing before the merger and corresponds to adding the size of country b to country a.

The second term in equation (28), $(1/2\rho)\,(W - S_a - S_b)(\xi_m^{ss} - \xi_a^{ss})$, measures the indirect negative effect of the merger, via a fall in openness. We call this effect the *trade reduction effect*. It corresponds to the increase in trade barriers between the regions of former country a and the rest of the world (i.e., all other countries except country b), brought forth by the larger size of the merged country (S_m). That is, this effect is due to the fact that the larger country will be less open with respect to the rest of the world.

Note that there is no guarantee that the net gain in terms of steady-state income (and growth) will be positive. That is, there is no guarantee that steady-state income per capita in the new, larger country will be higher than in country a—i.e., that $y_m^{ss} - y_a^{ss} > 0$.

From equation (24) we have:

$$\xi_a^{ss} = \frac{\xi}{2} - \lambda_a^{ss} = \frac{\xi}{2} - \frac{(1-\psi)(W - S_a)}{2\phi\rho} + \frac{\psi}{\phi}, \tag{29}$$

$$\xi_b^{ss} = \frac{\xi}{2} - \lambda_b^{ss} = \frac{\xi}{2} - \frac{(1-\psi)(W - S_b)}{2\phi\rho} + \frac{\psi}{\phi}, \tag{30}$$

$$\xi_m^{ss} = \frac{\xi}{2} - \lambda_m^{ss} = \frac{\xi}{2} - \frac{(1-\psi)(W - S_m)}{2\phi\rho} + \frac{\psi}{\phi}, \tag{31}$$

which, when substituted in equation (28), imply the following:

Proposition 4 *A necessary and sufficient condition for* $y_m^{ss} - y_a^{ss} > 0$ *is:*

$$S_m = S_a + S_b > \frac{3(1-\psi)W - 2\rho(\xi\phi + 2\psi)}{2(1-\psi)}. \tag{32}$$

The intuition for this results is as follows. A higher S_m means a bigger positive effect from the merger via the market size effect, because the two merging countries had larger barriers between themselves before the merger. A larger S_m (relative to W) also means that the rest of the world is relatively smaller, and therefore the openness reduction effect (with respect to the rest of the world) has smaller costs.

It is important to note that even if a merger increases income per capita, it does not necessarily imply an increase in consumption per capita and welfare. In order to calculate changes in consumption and welfare one should subtract the costs related to barriers reduction and any other costs associated with a merger. For example, a merger may bring about direct costs in order to eliminate internal barriers to trade. A merger may also imply higher "heterogeneity" costs due to different preferences over public goods, more costly coordination, etc.[25] In our empirical exercises we will focus on changes of income per capita.

2.6. Other Determinants of Steady-State Income Levels

In our model so far, different countries' steady-states differ only because (1) their size differs and (2) as a result, their level of openness also differs. There are obviously many other differences across countries, apart from size, that could yield differences in steady-state income levels and openness. In the context of our model, the ψ, ϕ and ρ parameters could differ across individual countries. Particularly patient countries, or countries where the costs of openness reduction are lower (for example through natural access to the sea, proximity to trading partners, and other geographic factors) will have higher levels of steady-state income and greater levels of openness, all else equal.

Such differences will not affect country a's growth performance under political integration with country b, unless they affect the other determinants of steady-state income levels and openness within country a. But it is easy to see that a merger between country a and country b, when they differ along these other dimensions, will change the growth effect of the merger on country a, *to the extent that the merger affects these values within country a*. We should stress again that this would only occur if country a's steady-state and openness determinants (other than its size and induced openness level) would change under political integration. This

25 On the costs of larger, more heterogeneous countries see Alesina and Spolaore (1997, 2003).

could occur as the result of factor movements such as migration or capital flows, or changes in geographic factors brought forth by the removal of borders.[26]

In the case where countries differ in ψ, ϕ and ρ, the thought experiment described above to evaluate the growth incidence of political mergers can be amended to account for changes in steady-state determinants under a merger. For example, if countries have different costs ϕ's, the analysis can be easily generalized as follows. Let ϕ_m denote the costs of barriers reduction in the unified country of size S_m. Then we have the following:

Proposition 5 *A political merger between a country of size S_a and a country of size S_b will increase income in country a in steady state (that is, $y_m^{ss} - y_a^{ss} > 0$) if and only if the following condition holds:*

$$S_b \left[\xi + \frac{\psi}{\phi_a} + \frac{\psi}{\phi_b} - \frac{(1-\psi)(W-S_a)}{\rho\phi_a} - \frac{(1-\psi)(W-S_b)}{\rho\phi_b} \right] > (W - S_a - S_b) \left[\frac{\psi}{\phi_m} - \frac{(1-\psi)(W-S_a-S_b)}{\rho\phi_m} - \frac{\psi}{\phi_a} + \frac{(1-\psi)(W-S_a)}{\rho\phi_a} \right]. \tag{33}$$

In what follows, we will label the effect of potential changes in steady-state determinants, besides openness and country size, as the *steady-state determination effect*.

3. Estimating the Growth Effect of Borders

In this section, we move from the theory to the data. That is, we describe the empirical strategy we pursue to estimate the effect of openness, country size and their interaction on economic growth and steady-state income levels, and then to calculate the growth effects of hypothetical mergers between pairs of countries. We start with the basic methodology to compute border effects on growth. This involves constructing a hypothetical merged country with characteristics of the underlying pair of countries. Using our underlying model for the endogenous determination of growth and openness, we can then calculate the growth rate this hypothetical country would have had in the absence of borders, and compare it to the actual growth rates of the merging countries.

We discuss various ways in which border effects can be calculated. In one scenario, we consider "size mergers" in which countries do not have barriers to the flow of goods but retain their own steady-state determinants (human capital, government size, investment rates, etc.). Under such a scenario, the border effect results only from the change in market size and the resulting endogenous response

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26 For instance, a previously landlocked country can gain easier access to the sea as a result of a political merger. This could affect the level of openness of the country, and consequently its growth rate. See for instance Sachs (2001), and Gallup et al. (1999) for evidence on the importance of geography for growth.

of openness levels. In another scenario, the other steady-state determinants (besides openness and country size) in the hypothetical merged country are population weighted averages from the original pair. We refer to this scenario as "full integration" since it amounts to assuming that under the merged state, each underlying country shares exactly the same steady-state determinants. We also briefly discuss how to calculate effects on steady-state income levels rather than growth rates.

3.1. Basic Methodology

The model presented above, specifically Propositions 1 and 2a, suggests that income in steady-state is positively related to both country size and openness, and that the effect of size is larger for less open countries. Hence, growth in the transition to the steady-state will also be a function of such variables. A specification consistent with those insights is:

$$\log \frac{y_{at}}{y_{at-\tau}} = \beta_0 + \beta_1 \log y_{at-\tau} + \beta_2 O_{at} + \beta_3 \log S_{at} + \beta_4 O_{at} \log S_{at} + \beta_5' Z_{at} + \varepsilon_{at} \tag{34}$$

where a refers to a country, S_{at} denotes country size, O_{at} denotes trade openness, y_{at} denotes per capita income, and Z_{at} is a vector of control variables. We have added additional determinants of steady-state income levels (the Z_{at} variables), which the model abstracts from, and an error term. The empirical predictions of our framework are that $\beta_2 > 0, \beta_3 > 0$ and $\beta_4 < 0$.

In our model, Propositions 2b and 3 suggests that openness is negatively related to country size. The second part of our econometric model reflects the negative relationship between trade openness and country size:

$$O_{at} = \alpha_0 + \alpha_1 \log S_{at} + \alpha_2' W_{at} + \nu_{at}, \tag{35}$$

where W_{at} is a vector of additional determinants of trade openness and the model predicts $\alpha_1 < 0$. In this econometric model, the exogenous variables are S_{at}, Z_{at} and W_{at}. We are considering the growth effect of an exogenous change in a country's size brought about by merging with a neighbor. Substituting equation (35) into (34), we obtain:

$$\log \frac{y_{at}}{y_{at-\tau}} = \gamma_0 + \gamma_1 \log y_{at-\tau} + \gamma_2 \log S_{at} + \gamma_3 (\log S_{at})^2 + \gamma_4' W_{at} \log S_{at} + \gamma_5 \nu_{at} \log S_{at} + \gamma_6' W_{at} + \gamma_7' Z_{at} + \mu_{at}, \tag{36}$$

where the γ coefficients are functions of the parameters of the growth and trade equations, as defined in Appendix 2.

Define ΔG_{abt} as the change in growth of country i resulting from its merger with country b. Since the only exogenous variable that has changed under a merger is country size, we term this particular exercise a "size merger".[27] We focus on

27 Below we will examine how to account for changes in the Z and W variables under a merger.

the expected effect on growth, as we have little knowledge of what the random component of growth or openness (captured by ε_{at} and ν_{at}) would have been had the countries been politically merged during the sample period.[28] Assuming $E(\nu_{at}|S_{at}, S_{mt}, W_{at}) = 0$, the expected effect on the growth rate of country a of merging with neighbor b, where the size of the merged country is denoted S_{mt} $(= S_{at} + S_{bt})$, is:

$$\begin{aligned}\Delta G_{abt} &\equiv E\left(\Delta \log \frac{y_{at}}{y_{at-\tau}} |S_{at}, S_{mt}, W_{at}\right) \\ &= \log\left(\frac{S_{mt}}{S_{at}}\right)\left[\gamma_2 + \gamma_3 \log\left(S_{at} S_{mt}\right) + \gamma_4' W_{at}\right]. \end{aligned} \tag{37}$$

Thus, the effect of the merger on growth is a multiple of the percentage increase in country size, where the multiplicative factor depends on the determinants of openness, the estimated parameters of the model and the sizes of countries a and b. Since our model predicts that $\gamma_3 = \beta_4 \alpha_1$ is positive, Proposition 3 is also directly apparent in equation (37).

In this basic setup, the induced effect of political integration on growth will depend on the home country's size, the size of the country it is considering merging with, and the determinants of the home country's trade openness volume. This combines three distinct effects of political integration on growth. Firstly, the direct (positive) effect of an increase in country size, equal to β_3 times the percentage increase in country size resulting from the merger ($\log(S_{mt}/S_{at})$). Secondly, the indirect (negative) effect through openness reduction, which is equal to $\beta_2 \alpha_1$ times the percentage increase in country size. Thirdly, the effect going through the interaction term, which captures the increasing impact of country size on growth as openness decreases. This effect, of ambiguous sign, depends on the determinants of a's openness level and the sizes of both a and b, and is equal to $\beta_4 \left(\alpha_0 + \alpha_1 \log\left(S_{mt} S_{at}\right) + \alpha_2' W_{at}\right)$ times the percentage increase in country size. It should be noted that the determinants of openness (W_{at}) and the sizes of countries a and b can be such that the openness reducing effect of political integration outweighs the positive direct scale effect of merging. In this case, ΔG_{abt} will be negative.

Finally, an exogenous change in openness yielding an equivalent expected change in economic growth without a political merger can be computed using equation (34) as:

$$E(\Delta O_{at}|S_{at}, S_{mt}, W_{at}) = \frac{\Delta G_{abt}}{\beta_2 + \beta_4 \log S_{at}}. \tag{38}$$

The benefits of exogenous increases in openness can thus be directly compared to those of bilateral political mergers.

28 In Section 3.3 below, we discuss an alternative method that allows us to include the error term component of the growth effect of mergers, using the estimated values of error term in the original countries.

3.2. Changes in Conditioning Variables

Equations (37) and (38) implicitly assume that a political merger does not affect the determinants of the home country's steady-state income level, or the determinants of its openness levels, *other than country size*. For example, if France had been merged with Italy, France and Italy would each have retained their own Z_{at} and W_{at} variables. These may include the savings rate, investment in human capital, characteristics of governance and government involvement in the economy, and gravity type factors such as geographic variables. As suggested in Section 2.6, this is clearly an extreme assumption since factors other than the size of the population alone would likely be different in each merged country under political integration, affecting both growth and the degree of openness. For example, increased migration and capital mobility across countries a and b under a merger will imply that the rates of investment in human and physical capital will differ compared to what they would have been in the separate countries. Taking this *steady-state determination effect* into consideration generates an additional sources of ambiguity in the sign of the overall effect of political integration on economic growth. Clearly, this effect would tend to be negative for the home country when the hypothetical merger is with a country with "worse" overall determinants of the steady-state income level than itself.

We can relax the assumption that political integration affects growth only through country size and the induced effect of changes in country size on trade openness by assuming that other conditioning variables will change in both merged units after political integration, and in particular that they will take on the same value in a and b under a merger. We term this alternative scenario "full integration".[29]

There are obviously many ways to specify what values the other determinants of growth (the Z variables) and openness (the W variables) will take under full political integration.[30] One reasonable assumption is that each of the merged countries would end up with the same population weighted average of the initial conditioning variables, which we can denote Z_{mt} and W_{mt}, where the subscript m denotes that a political merger has occurred and that the resulting variables are,

29 There are obviously many ways to carry out the calculation of "full integration" effects. The proper interpretation of a hypothetical merger between two countries a and b in this paper is "what would growth have been had the border between a and b not existed". The intepretation of our counterfactual is not "what would the growth rate of the merged countries have been over 1960–1989 if the two countries had merged in 1960". If that were the case, we would have to consider the gradual adjustment of income (and possibly of the steady-state determinants and openness) across the two countries, post-1960. While this would be an interesting alternative assumption to explore, it is beyond the scope of this paper and we leave the corresponding analysis for future work.

30 For example, we could assume that the merged country is assigned the best—or worst—values of the Z and W variables from each of country a and b. We choose an intermediate—and more reasonable—assumption by assigning to the merged country the population-weighted average of these variables from countries a and b.

where applicable, the population weighted averages of the regional measures.[31] The resulting effect of a political merger on growth, ΔG^m_{abt}, is then computed as:

$$\begin{aligned}\Delta G^m_{abt} \equiv & E\left(\Delta \log \frac{y_{at}}{y_{at-\tau}} | S_{at}, S_{mt}, W_{at}, W_{mt}, Z_{at}, Z_{mt}\right)\\ = & \log\left(\frac{S_{mt}}{S_{at}}\right)\left(\gamma_2 + \gamma_3 \log\left(S_{at} S_{mt}\right) + \gamma_4' W_{at}\right)\\ & + \gamma_1 \log \frac{y_{mt-\tau}}{y_{at-\tau}} + \left[\gamma_4' \log S_{mt} + \gamma_6'\right]\left(W_{mt} - W_{at}\right) + \gamma_7'\left(Z_{mt} - Z_{at}\right). \qquad (39)\end{aligned}$$

This formulation includes the same size effects as equation (37), namely those that occur through the direct effect of market size, the indirect effect through trade reduction and the changes in the interaction term. But in addition to these effects, we now have the steady-state determination effect, equal to the terms in the second line of equation (39).[32] An important consequence of this framework is that, under full political integration, expected growth will be equal for both country a and country b.[33]

To summarize, equations (37) and (39) result from two different assumptions about the effects of political integration on growth; one with complete averaging of steady-state determinants ("full integration"), the other with no changes in these variables ("size merger"). The effect of a hypothetical merger likely falls in between these two extremes. The corresponding estimates should therefore be viewed as extreme bounds on the effects of bilateral political mergers on economic growth.

3.3. *Alternative Assumptions and Extensions*

So far, we have focused on estimating the *expected* effects of political mergers on growth, disregarding the unexplained portion of growth and openness in our counterfactual exercises. Whether to consider the residuals μ_t and ν_t from the growth and openness equations when evaluating the effects of borders on growth is largely a matter of interpretation. On the one hand, if one believes that they reflect omitted determinants of growth and openness, then they should be treated

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31 Of course, in the case of the land area, the merged variable is the sum of the corresponding areas of countries a and b. For the dummy variables in our specification, the definitions of the merged variables are as follows: the merged country is landlocked if *both* a and b are landlocked; the merged country is an island if *both* a and b are islands; the merged country is an oil exporter if *either* a or b is an oil exporter.

32 We can further decompose the steady-state determination effect into the term $\gamma_1 \log \frac{y_{mt-\tau}}{y_{at-\tau}}$ which reflects differences in initial income and the terms that are functions of $(W_{mt} - W_{at})$ and $(Z_{mt} - Z_{at})$, which reflect differences in steady-state determinants proper. For identical values of the Z and W variables, if country a starts out with an initial income that is lower than country b's, full integration will slow a's growth simply because it will raise its initial income—the force of convergence implies that countries grow slower, the closer they are to their steady-states.

33 This is not the case when we do not take into account the steady-state determination effect (Section 3.1), because post-merger Z and W variables still differ across a and b.

as another steady-state determinant (analogous to the W and Z variables). As it turns out, since the explained portion of growth and openness are typically on the order of 50 and 60% respectively, in our baseline regressions, accounting for the unexplained components of growth and openness could alter our estimates of the merger effects. On the other hand, if one believes that the residuals reflect true "randomness", then there is no good justification for including them in the analysis: we do not know what the random component of growth would have been, had the countries been merged over the sample period. Since both interpretations seem equally defensible, we also present merger effects that take into account the estimated residuals. Fortunately, we can easily accommodate this change in our basic empirical methodology, as we do in Appendix 3A. In Section 4, we present estimates both with and without the residual effects, for both size mergers and full integration. Our result do not depend much on alternative treatments of the error term.

A second extension we pursue in our empirical work is to consider the effects of borders on steady-state income levels rather than growth rates. As explained in the theoretical section, because our model shares the dynamic features of the neoclassical growth model, it is straightforward to present our results in terms of steady-state income levels rather than growth. We do not observe steady-state income, but it can be estimated readily under the assumptions of our framework, because the right-hand side variables of equation (34) are the determinants of steady-state income levels. We show how to compute border effects on steady-state income levels in Appendix 3B, and present the corresponding estimates in Section 4.

4. Empirical Results

4.1. Estimates of the Growth and Openness Equations

4.1.1. Data and Estimators

Equations (34) and (35) can be readily estimated using cross-country data on growth, country size, openness and other control variables. Our measure of openness consists of the ratio of imports plus exports to GDP, a commonly used indicator of a country's overall level of openness (this corresponds closely to the measure derived in the theory of Section 2). The measure of country size consists of the log of a country's population. The Z_{it} variables are the common determinants of steady-state income levels in the cross-country literature: male and female human capital, the fertility rate, the ratio of government consumption to GDP and the rate of physical capital investment (see Barro and Sala-i-Martin (1995), chapter 12). Finally, the W_{it} variables consist of common determinants of openness such as geographic factors (land area, whether a country is landlocked or an island, whether it is an oil exporter) and the terms of trade shocks. In order to capture long-term phenomena, variables are averaged, where appropriate, over the sample period.

Our base estimates for calculating merger effects are based on PPP per capita income data from version 5.6 of the Penn World Tables (PWT). This 1960–1989 sample consists of 92 countries. Version 6.1 of this dataset has recently been circulated, extending the data to 1998.[34] We use these data for the purpose of reestimating equations (34) and (35), as a robustness check. However, because some of the other conditioning variables are not as readily available for recent years, the updated sample only features 77 countries. Moreover, some "important" countries such as Germany are not part of this dataset for the entire sample period, precluding any calculation of the effect of political mergers on growth for such a key country in Europe.[35] Therefore, in order to maximize the number of mergers we consider, and to base our estimates on the largest possible sample, we use estimates from version 5.6 of the PWT for the purpose of calculating merger effects. As shown below, the estimates of equations (34) and (35) do not differ much between versions of the PWT, so we are confident that using the more recent data would not alter our results other than by limiting the country coverage.[36]

One issue that arises clearly from our theoretical and empirical models is the endogeneity of openness (and the interaction term between openness and country size) in the growth equation. To address this, we treat equations (34) and (35) as a system of simultaneous equations to be estimated jointly. Our baseline results therefore consist of three-stage least squares estimates (3SLS). 3SLS treats all of the exogenous variables in the system (i.e. country size, initial per capita income, Z_{it} and W_{it}) as potential instruments for the endogenous variables in the system (growth, openness and the interaction term between openness and country size). Given that openness and the interaction term are the only endogenous variables to appear on the right hand side of either equation in the system, only the W_{it} variables serve as instruments for them in the growth regression. As noted above, these variables consist of plausibly exogenous geographic and terms of trade variables. In addition to these instruments, we can gain precision by using additional instruments which do not necessarily appear as exogenous variables in either the trade or the growth equations.[37] Finally, 3SLS allows for cross-equation covariance

34 See http://pwt.econ.upenn.edu/.

35 In the case of Germany, this is due to reunification in 1989. The new version of the PWT only features data for reunified Germany since 1990. Our estimates of merger effects refer to West Germany prior to 1990.

36 Moreover, using PWT 5.6 may actually preferable to using later PWT for the 1960–1989 period because the PWT 5.6 puts much more weight on 1960–1989 benchmarks than later versions (which use benchmarks from the 1990s to adjust income estimates for the 1960–1989 period). We are grateful to an anonymous referee for pointing this out.

37 Following ASW, these are dummy variables for small countries, small islands, and the interaction terms between population and the each of dummy variables for small countries, small islands, islands, and landlocked countries. As long as they are jointly excludable from the growth regression, geographic variables such as these are likely to be plausibly exogenous with respect to growth, yet affect the level of openness. See Frankel and Romer (1999) for further details on employing geographic variables to instrument for openness in growth regressions, and for arguments that these variables are indeed excludable from a growth specification when other determinants of growth are controlled for.

in the error terms ε_{it} and ν_{it}, generating potential efficiency gains.[38] For the sake of robustness, we also present results obtained from seemingly unrelated regression (SUR), as well as regressions excluding the Z_{it} and W_{it} control variables.

4.1.2. Baseline Results

Tables 1 and 2 display results for the joint estimation of equation (34) and (35). The baseline estimates used for the merger calculations appear in column (1). The theoretical predictions are borne out empirically. Specifically, openness and country size are positively and significantly related to growth, while their interaction enters negatively and significantly. This is consistent with the model's insights (Propositions 1 and 2a), and extends related findings in ASW, Ades and Glaeser (1999) and Alcalá and Ciccone (2003). Moreover, as expected, country size affects openness negatively. This is consistent with our theoretical insights (Propositions 2b and 4), and extends previous findings in Alesina and Wacziarg (1998) and Wacziarg (2001).

Several additional observations are called for. First, the pattern of signs and statistical significance is unchanged when the Z_{it} and the W_{it} control variables are excluded from the system, and the magnitude of the coefficients of interest is raised (column 2). While this specification is likely to be tainted by omitted variables bias, it corresponds directly to the relationships derived from theory, where countries differed in no other way than size and openness. It is therefore reassuring that the predictions of the theory hold unconditionally as well as conditionally. Second, as in Frankel and Romer (1999), instrumenting for openness using geographic variables increases the magnitude of the estimated coefficient on trade openness compared to the specifications that do not account for the endogeneity of openness (SUR estimates are presented in column 3).

Since SUR estimates are tainted by endogeneity bias and since the unconditional estimates of column 2 are tainted by omitted variables bias, we rely on the 3SLS estimates of column 1 as our benchmark to compute border effects. These estimates are not sensitive to small changes in the list of instruments or control variables. In fact, as argued in ASW and further shown here, the pattern and magnitude of coefficients on openness, country size and their interaction are remarkably robust, whether in cross-sectional or in panel (random effects) applications. As a consequence, it is also the case that our estimates of the effects of borders on growth and income levels are quite robust to changes in the specification.

Table 3 presents various diagnostic tests for our model specifications. The first panel presents first stage F-tests, obtained from simple OLS regressions of openness and the interaction term on all of the exogenous variables in the system, and testing the joint significance of the instruments. There are two endogenous variables appearing on the right-hand side of the growth equation: openness, and its interaction with log population. The F-tests demonstrate that the instruments are

38 See Wacziarg (2001) for further technical details on the use of 3SLS to estimate systems of equations in a cross-country growth context.

Table 1. System estimates of the growth equation.

	(1) 3SLS	(2) 3SLS	(3) SUR	(4) 3SLS	(5) 3SLS	(6) SUR
	PWT 5.6, 1960–1989			PWT 6.1, 1960–1998		
Log population	0.678 (0.185)**	1.337 (0.254)**	0.263 (0.134)*	0.472 (0.249)*	1.387 (0.311)**	0.130 (0.136)
Openness* log population	−0.007 (0.003)**	−0.007 (0.004)*	−0.003 (0.002)	−0.005 (0.004)	−0.009 (0.006)	−0.001 (0.002)
Openness	0.081 (0.023)**	0.118 (0.032)**	0.040 (0.017)**	0.055 (0.036)	0.124 (0.048)**	0.010 (0.019)
Log 1960 per capita income	−1.120 (0.269)**	0.120 (0.205)	−1.262 (0.245)**	−1.437 (0.321)**	0.322 (0.216)	−1.611 (0.263)**
Fertility rate	−0.185 (0.121)		−0.308 (0.114)**	−0.601 (0.152)**		−0.717 (0.136)**
Male human capital	1.550 (0.443)**		1.745 (0.402)**	0.079 (0.317)		0.010 (0.295)
Female human capital	−1.183 (0.472)**		−1.415 (0.433)**	0.162 (0.395)		0.165 (0.373)
Government consumption ratio	−0.053 (0.020)**		−0.061 (0.019)**	−0.024 (0.018)		−0.031 (0.017)*
Investment rate	0.091 (0.024)**		0.087 (0.022)**	0.073 (0.026)**		0.075 (0.021)**
Constant	2.217 (3.327)	−14.447 (2.760)**	8.676 (2.662)**	9.783 (4.697)**	−16.243 (3.574)**	15.415 (3.127)**
R^2			0.68			0.73

Standard errors in parentheses; *: significant at 10%; **: significant at 5%.
Notes: (a) Ninety two observations in columns (1) to (3), 77 observations in columns (4) to (6).
(b) The R^2 is not well-defined for 3SLS regressions and is not reported.
(c) Instruments for openness and the interaction of openness and log population in the 3SLS specifications: small country dummy, small island dummy, island dummy, landlocked country dummy, the interactions of these 4 last variables with the log of population, log population, log initial income 1960, log land area, terms of trade shocks, oil dummy.

Table 2. System estimates of the openness equation.

	(1) 3SLS	(2) 3SLS	(3) SUR	(4) 3SLS	(5) 3SLS	(6) SUR
	PWT 5.6, 1960–1989			PWT 6.1, 1960–1998		
Log population	−6.744 (2.671)**	−15.003 (2.254)**	−5.862 (2.699)**	−7.723 (3.185)**	−15.356 (2.935)**	−7.093 (3.213)**
Log 1960 per capita income	1.335 (3.868)	3.378 (4.139)	1.888 (3.902)	1.526 (4.802)	0.753 (5.314)	1.696 (4.826)
Log land area	−9.868 (2.124)**		−10.537 (2.179)**	−10.511 (2.542)**		−11.271 (2.596)**
Terms of trade shocks	−45.202 (205.930)		48.984 (221.254)	373.600 (291.622)		377.467 (302.285)
Oil dummy	13.999 (21.898)		9.771 (23.596)	−13.199 (28.132)		−15.031 (29.393)
Landlock dummy	−2.472 (8.889)		1.807 (9.602)	−6.386 (10.285)		−5.702 (10.772)
Island dummy	3.186 (7.766)		4.337 (8.351)	12.643 (9.934)		11.276 (10.385)
Constant	161.089 (33.890)**	169.337 (34.354)**	152.610 (34.432)**	253.343 (47.309)**	196.654 (49.215)**	255.884 (47.731)**
R^2			0.51			0.51

Standard errors in parentheses; *: significant at 10%; **: significant at 5%.
Notes: (a) Ninety two observations in columns (1) to (3), 77 observations in columns (4) to (6).
(b) The R^2 is not well-defined for 3SLS regressions and is not reported.

Table 3. Diagnostic tests.

	Distribution of the test statistic	Value of the test statistic	p-Value
First stage F-tests			
Col. (1)-3SLS, Openness	$F(11, 73)$	3.11	0.002
Col. (1)-3SLS, Openness*log population	$F(11, 73)$	3.09	0.002
Col. (2)-3SLS, Openness	$F(11, 78)$	3.55	0.0005
Col. (2)-3SLS, Openness*log population	$F(11, 78)$	3.72	0.0003
Col. (4)-3SLS, Openness	$F(11, 58)$	2.40	0.016
Col. (4)-3SLS, Openness*log population	$F(11, 58)$	2.77	0.006
Col. (5)-3SLS, Openness	$F(11, 63)$	3.15	0.002
Col. (5)-3SLS, Openness*log population	$F(11, 63)$	3.47	0.0008
SUR diagnostics			
Col. (3)-SUR, Cross-equation ρ[a]		−0.077	
Col. (3)-SUR, Breusch-Pagan statistic[b]	$\chi^2(1)$	0.553	0.457
Col. (6)-SUR, Cross-equation ρ[a]		−0.067	
Col. (6)-SUR, Breusch-Pagan statistic[b]	$\chi^2(1)$	0.345	0.557
Overidentification tests			
Col. (1)-3SLS, Hausman test[c]	$\chi^2(8)$	0.710	0.999
Col. (2)-3SLS, Hausman test[c]	$\chi^2(6)$	1.050	0.984
Col. (4)-3SLS, Hausman test[c]	$\chi^2(7)$	1.520	0.982
Col. (5)-3SLS, Hausman test[c]	$\chi^2(6)$	13.320	0.038
Sargan statistic, single equation IV, 1960–89 data[d]	$\chi^2(9)$	11.236	0.260
Sargan statistic, single equation IV, 1960–98 data[d]	$\chi^2(9)$	8.458	0.489

[a] The cross-equation ρ is the correlation of the error terms of the growth and openness equations using the SUR estimator.
[b] The Breusch–Pagan statistic (distributed $\chi^2(1)$) is used to test the null of independence of the residuals across the growth and openness regressions.
[c] The Hausman test is based on comparing the estimates from a consistent estimator to those of an estimator which is consistent and efficient under the null hypothesis of valid overidentifying restrictions. The maintained instruments for the assumed consistent estimator are the small country dummy and its interaction with log population, as in Alesina, et al. (2000); Hausman tests obtained from different assumptions led to similar results and are available upon request.
[d] Sargan tests of overidentifying restrictions in the growth equation are shown for the specifications of columns (2) and (5), but using single equation IV instead of 3SLS (the regression output, not shown, is available upon request).

jointly related to the variables they are instrumenting for, at high levels of statistical significance, no matter which specification is considered.[39]

In the second panel of Table 3, we present diagnostic tests pertaining to the SUR estimates of the system parameters. Simple cross-equation error correlations and Breusch–Pagan tests suggest that the residuals across equations are largely independent. This is encouraging as it suggests that the possible misspecification of one equation does not "contaminate" estimates of the other.[40] On the other hand, there may not be much of a gain from using single-equation estimators rather than system estimators. We choose to report system estimates, but the results are robust to using single equation methods instead.

Finally, we conducted tests of overidentifying restrictions for the 3SLS estimates. The first set of tests are Hausman specification tests.[41] Since there are only two endogenous variables appearing on the right-hand side of each equation, an exactly identified system would require two instruments. Following ASW, we choose the small country dummy and its interaction with log population as the "maintained" instruments when computing Hausman tests. Comparing estimates obtained from using only these two instruments to those of our baseline specification (Column 1 of Tables 1 and 2) yields a $\chi^2(8)$-distributed Hausman test statistic of 0.710, with a p-value of 0.99, so we fail to reject the null of valid overidentifying restrictions (other specifications yield similar results). Another test we carried out was the Sargan test, applied to single-equation IV estimates of the growth equation (these estimates were very close to those obtained with 3SLS). For the baseline specification, the $\chi^2(9)$-distributed Sargan test statistic bears a value of 11.24, with a p-value of 0.26, so we again fail to reject the null of valid overidentifying restrictions in the IV specification of the growth equation, increasing our confidence in the validity of the instruments.[42]

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39 Note that the Staiger–Stock rule of thumb for weak instruments, which states that first stage F-statistics should be greater than 10, applies only to the case of one endogenous regressor. We have two endogenous regressors in our application. Further, Shea's R^2 statistics, available upon request, bore high magnitudes, alleviating concerns about weak instruments.

40 We are grateful to an anonymous referee for pointing this out. In fact, equation-by-equation OLS estimates were remarkably similar to SUR estimates, and equation-by-equation IV estimates were very similar to 3SLS estimates (on the other hand, SUR estimates do differ in magnitude from 3SLS estimates, so accounting for the endogeneity of openness and the interaction term does matter). Single equation results are available upon request.

41 We do not perform Hausman tests to test for the presence of endogeneity, as is commonly done. Rather, we use them as tests of the overidentifying restrictions. Under the null of valid overidentifying restrictions, the 3SLS estimates using all instruments are consistent and efficient. 3SLS estimates using only a subset of "maintained" instruments are consistent but not efficient under the null. This can serve as a basis for testing the validity of the overidentifying restrictions using a Hausman test.

42 Tests of overidentification tend to have low power in the presence of other specification problems. The Hausman test, for instance, relies on specifying at least two valid instruments, often a very strong assumption. While we should not overinterpret these tests, the results remain encouraging. Moreover, similar tests appeared in ASW, who also concluded that the geographic determinants of openness were excludable from the growth regression, suggesting they were valid instruments. Related to this, Frankel and Romer (1999) showed that an instrumental variable

4.1.3. *Robustness*

Our baseline results hold up when using the updated PWT 6.0 dataset for the period 1960–1998, despite the loss of 15 data points (Tables 1 and 2, columns 4–6). Due to this smaller sample, estimates are sometimes less statistically significant, but the pattern of signs and the magnitude of the coefficients are unchanged compared to the 1960–1989 dataset. Therefore, we are confident that our estimates of the border effects on growth would be qualitatively unchanged if we were to use coefficients from the updated dataset. As explained above, we refrain from using estimates obtained from the smaller dataset as this would result in a loss of 15 countries, in particular Germany.

The second robustness issue that we examine relates to our measure of openness. In an important paper, Alcalá and Ciccone (2004) have argued that commonly used volume measures of trade openness, obtained by taking the ratio of imports plus exports in exchange rate US dollars to GDP in exchange rate US dollar, may be inappropriate. The explanation is quite simple. Suppose that trade openness raises productivity, but does so more in the tradable than in the nontradable sector (a plausible assumption). This will lead to a rise in the relative price of nontradables, and a fall in conventionally measured openness under the assumptions that the demand for nontradables is relatively inelastic, because it may raise the denominator of the conventional measure of openness more than the numerator. So one may observe trade-induced productivity increases going hand in hand with a decline in conventional measures of openness. Alcalá and Ciccone propose an alternative measure, "real openness", defined as the ratio of imports plus exports in exchange rate US$ to GDP in PPP US$. This alternative measure will address the problem, since the denominator now corrects for international differences in the price of nontradable goods.

Tables 4 and 5 (columns 1 and 2) present 3SLS estimates of our baseline model using Alcalá and Ciccone's "real openness" measure, still using version 5.6 of PWT for the 1960–1989 period.[43] In both specifications with and without controls, our results on growth are confirmed and strengthened. Column 2 of Table 4 reveals an effect of openness on growth that has increased by 50% compared to the corresponding entry in Table 1. The magnitude and significance of the interaction term has also increased, while the magnitude of the coefficient on the log of population has decreased somewhat. In Table 5, while the effect of country size on openness still has a negative sign, its statistical significance and magnitude have fallen. Again, these results based on an alternative measure of openness suggest our baseline coefficients are quite robust, and may even understate the effect of openness on growth.

The last robustness check that we perform consists of testing our theory in a panel rather than a cross-sectional context. While the cross-sectional approach is

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constructed from the geographic determinants of trade volumes were excludable from a regression of income levels on trade volumes.

43 We thank Antonio Ciccone for providing us with the data.

Table 4. Growth equation—robustness checks (estimator: 3SLS).

	Alcala-Ciccone openness measure		4 Decade panel (1960–2000)	
	(1)	(2)	(3)	(4)
Log population	1.174 (0.293)**	0.447 (0.205)**	0.761 (0.144)**	0.437 (0.144)**
Open*log Pop	−0.019 (0.009)**	−0.012 (0.006)**	−0.009 (0.002)**	−0.005 (0.002)**
Openness	0.233 (0.074)**	0.122 (0.050)**	0.096 (0.019)**	0.055 (0.019)**
Log per capita income 1960	−0.489 (0.267)*	−1.514 (0.269)**	0.167 (0.112)	−1.056 (0.227)**
Fertility rate		−0.343 (0.128)**		−0.408 (0.109)**
Male human capital		1.619 (0.467)**		0.341 (0.249)
Female human capital		−1.229 (0.489)**		−0.232 (0.294)
Government consumption ratio		−0.060 (0.021)**		−0.032 (0.012)**
Investment rate		0.083 (0.027)**		0.094 (0.016)**
# Countries (# periods)	88 (1)	88 (1)	99 (4)	79 (4)

Standard errors in parentheses; *: significant at 10%; **: significant at 5%.
Notes: (a) The R^2 is not well-defined for 3SLS regressions and is not reported.
(b) The regression in column 4 includes period fixed effects (output omitted). Other regressions include an intercept term (output omitted).

Table 5. Openness equation–robustness checks (estimator: 3SLS).

	Alcala–Ciccone openness measure		4 Decade panel (1960-2000)	
	(1)	(2)	(3)	(4)
Log population	−7.692 (1.852)**	−1.895 (2.293)	−10.364 (1.218)**	−8.541 (1.741)**
Log per capita income 1960	11.608 (3.275)**	10.761 (3.288)**	8.570 (1.742)**	2.781 (2.038)
Log land area		−7.302 (1.854)**		−5.611 (1.454)**
Terms of trade shocks		17.399 (179.445)		38.631 (12.662)**
Oil dummy		6.263 (19.024)		11.128 (9.927)
Landlock dummy		−0.138 (7.921)		−3.869 (6.130)
Island dummy		−0.776 (6.830)		0.132 (5.622)
# Countries (# periods)	88 (1)	88 (1)	99 (4)	79 (4)

Standard errors in parentheses; *: significant at 10%; **: significant at 5%.
Notes: (a) The R^2 is not well-defined for 3SLS regressions and is not reported.
(b) The regression in column 4 includes period fixed effects (output omitted). Other regressions include an intercept term (output omitted).

preferable to capture the long term relationship between growth, openness and country size, and is now usual in the literature linking trade and productivity, a panel approach using decade averages may provide efficiency gains while still maintaining a relatively long horizon. We used the latest version of the PWT (version 6.1) and construct a panel of four decades spanning 1960–2000.

We formulated a system of equations with two equations per period (one for the determination of growth and the other for trade openness), and constrained slope coefficients to equality across periods. We then ran 3SLS on this eight equation system.[44] Results are displayed in Tables 4 and 5 (columns 3 and 4). Once again, our results are qualitatively unchanged. In the growth equation (column 4 of Table 4), estimates on openness, log population and their interaction are very close to those obtained in the corresponding entry of Table 1 (column 4), and similarly for the effect of country size on openness in Table 5.

4.2. The Effects of Hypothetical Mergers

4.2.1. Effects on Expected 1960–1989 Growth

The parameter estimates presented in Tables 1 and 2 can be used to calculate, for pairs of adjacent countries, what their growth rate would have been had they formed a single country over the sample period under consideration.[45] Namely, we can now calculate the impact of specific borders on growth, under alternative definitions of political integration. As described above, under a "size merger", which is reflected in equation (37), a political merger simply entails full access to the neighbor's markets, without any change in the home country's W_{at} and Z_{at} variables. Under "full integration", reflected in equation (39), both hypothetically merged countries share the same initial incomes, W_{at}^m and Z_{at}^m, and therefore the same growth rate under political integration. Since there is no *a priori* reason to prefer one definition over the other, we calculate the effect of borders under both definitions, and further decompose this effect into the direct positive effect of an increase in country size, the indirect negative effect via openness reduction, the ambiguous effect via the interaction term, and the steady-state determination effect.

Table 6 shows summary statistics for these various effects based on 123 hypothetical pairwise mergers. A salient feature of these statistics is the wide dispersion of the various effects. The pure size effect on growth, ΔG, has a standard deviation of 0.377 and a positive mean of 0.123 percentage points of growth annually, suggesting that the average country would have benefitted from merging with a neighbor based on increased size alone (interestingly, even a country at the 25th percentile would benefit slightly). Indeed, the direct effect of size on growth, on average, more than outweighs the indirect effect via openness reduction (while the interaction effect is on average very close to zero). Under a full integration scenario, however, a typical country would have lost slightly, on the order of $\Delta G^m = -0.112$ percentage points of annual growth. Since the difference between ΔG^m and ΔG is equal to the steady-state determination effect, the latter is on average negative (and equal to -0.235). Therefore, borders shield the

44 For further details on panel-3SLS estimators, see Wacziarg (2001).

45 We also considered mergers between proximate islands and up to five neighboring countries, such as the United Kingdom and Ireland, or the United Kingdom and France. Our results pertain to a total of 123 hypothetical mergers of country pairs (i.e. 246 merger experiments).

Table 6. Summary statistics of the effects of border removals (based on Tables 1 and 2, column (1) estimates).

Variable	Mean	Std. dev.	25th pctile	50th pctile	75th pctile	Min	Max
Observed average growth	2.127	1.671	1.059	2.252	3.013	−1.231	6.580
Fitted growth	2.167	1.369	1.138	2.059	2.995	−0.006	6.150
Direct effect of size	0.745	0.743	0.149	0.480	1.158	0.005	3.452
Indirect effect via openness reduction	−0.601	0.600	−0.934	−0.387	−0.120	−2.784	−0.004
Effect via change in interaction term	−0.021	0.405	−0.025	0.028	0.102	−2.400	1.056
Steady-state determination effect	−0.235	0.678	−0.507	−0.077	0.066	−3.442	2.350
ΔG (size merger)	0.123	0.377	0.028	0.088	0.250	−1.733	1.367
ΔG^m (full integration)	−0.112	0.914	−0.363	−0.004	0.187	−4.965	3.350
Openness equivalent (size merger)	10.184	22.517	1.140	5.306	13.873	−40.281	184.332
Openness equivalent (full integration)	0.403	43.089	−16.308	−0.344	12.085	−144.379	315.772
ΔG^e (size merger with residual effect)	0.097	0.524	0.016	0.083	0.236	−4.214	1.511
ΔG^{me} (full integration with residual effect)	−0.092	1.047	−0.427	−0.024	0.249	−4.036	4.220
ΔSSY (level effect, size merger), %	10.976	33.623	2.454	7.847	22.355	−154.651	121.956
ΔSSY^m (level effect, full integration), %	−2.068	83.400	−19.665	2.131	22.824	−421.068	325.630

Notes: (a) Summary statistics based on 246 effects calculated from 123 hypothetical political mergers.
(b) ΔG (size merger) is the sum of the direct effect of size, the indirect effect via openness reduction, and the effect via the change in the interaction term.
(c) ΔG^m (full integration) is the sum of ΔG (size merger) and the steady-state determination effect.
(d) The openness equivalent is the percentage point increase in the trade to GDP ratio needed to achieve a change in growth equivalent to merging with a neighbor (equation 37 in text).
(e) ΔG^e is ΔG plus the residual effect, as explained in Section 3.3 and Appendix 3.
(f) ΔG^{me} is ΔG^m plus the residual effect, as explained in Section 3.3 and Appendix 3.
(g) ΔSSY and ΔSSY^m are the steady-state level effects of a "size merger" and "full integration", respectively.

average country from slow growing neighbors. However, the median effect, equal to −0.077, is closer to zero.[46]

46 This is not surprising. Since the steady-state determination effect is obtained largely from population weighted average of steady-state determinants, when two countries consider merging the poorer one will stand to gain from better steady-state determinants, while the richer one will stand to lose. Thus, we should see roughly half the sample of 246 effects display positive effects, and the other half negative ones (this is only roughly true because under integration some variables, such as the landlocked country dummy and land area, are not simply averages of the underlying variables for the two merging countries). While the median effect is expected to be close to zero, the average effect is negative: the countries with positive effects display effects smaller in absolute value than those that suffer negative effects. This could reflect the fact that the former set of countries (the ones with worse steady-state determinants) is composed of

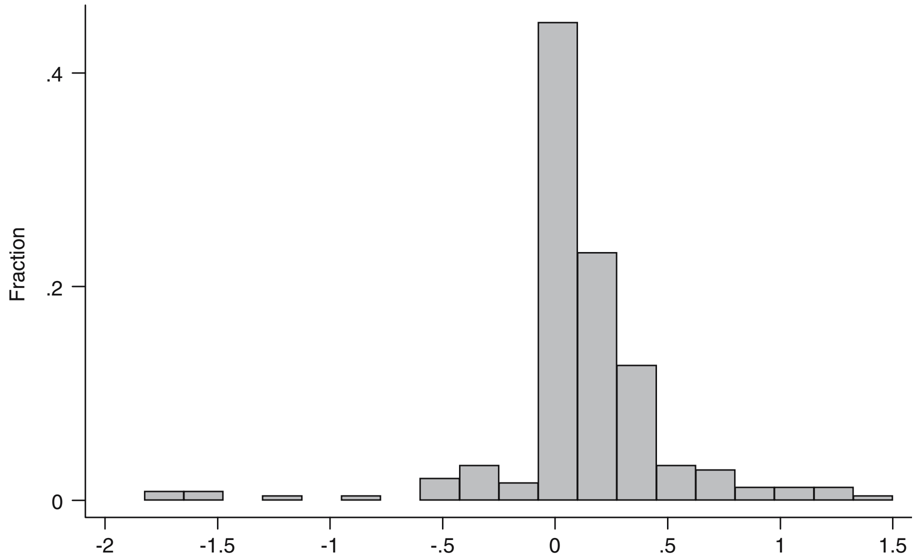

Figure 1. Total effect of size merger on growth.

There is a wide dispersion of these effects around their mean. This suggests that these simple summary statistics mask relevant country-specific features of the border effect on growth. The percentiles presented in Table 6 more information on the distribution of the effects, and Figures 1 to 8 provide an even more complete picture. They plot the distributions of the estimated effects. The total size effect ΔG is generally positive but moderate, in most cases smaller than 0.5 percentage points of annual growth. The effect of full political integration ΔG^m is more symmetrically distributed around zero, with slightly fatter tails. Turning to the decomposed effects confirms previous observations, namely that the interaction term effect is tightly distributed around zero, while the steady-state determination effect is slightly skewed, with a negative mean.

4.2.2. An Example: France and Italy

While these summary statistics and plotted distributions are useful, they are no substitute for the estimates obtained individually for each pair of adjacent countries. A close examination of these specific estimates reveals that their magnitudes are very sensible and that their signs are as expected. Small countries merging

relatively large countries in population terms, for which merging with a small neighbor does not represent a large change in steady-state determinants.

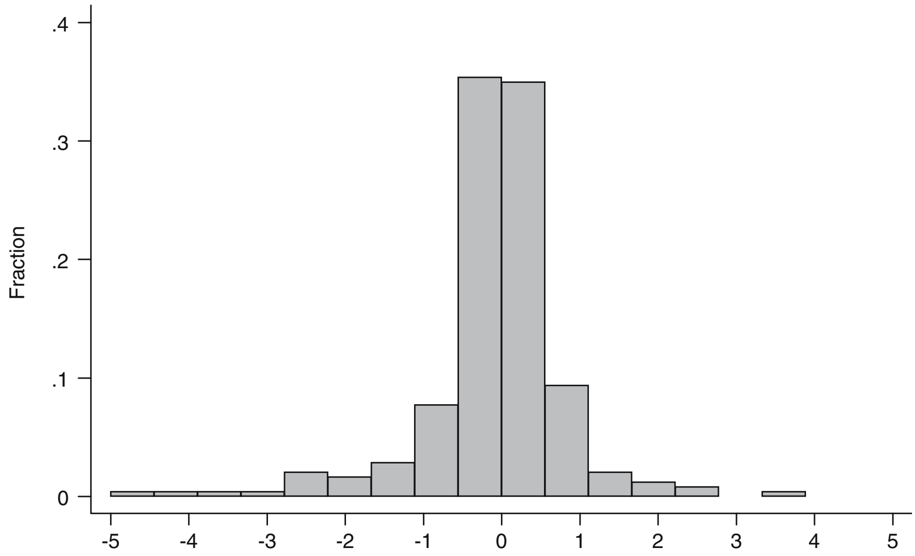

Figure 2. Total effect of full integration on growth.

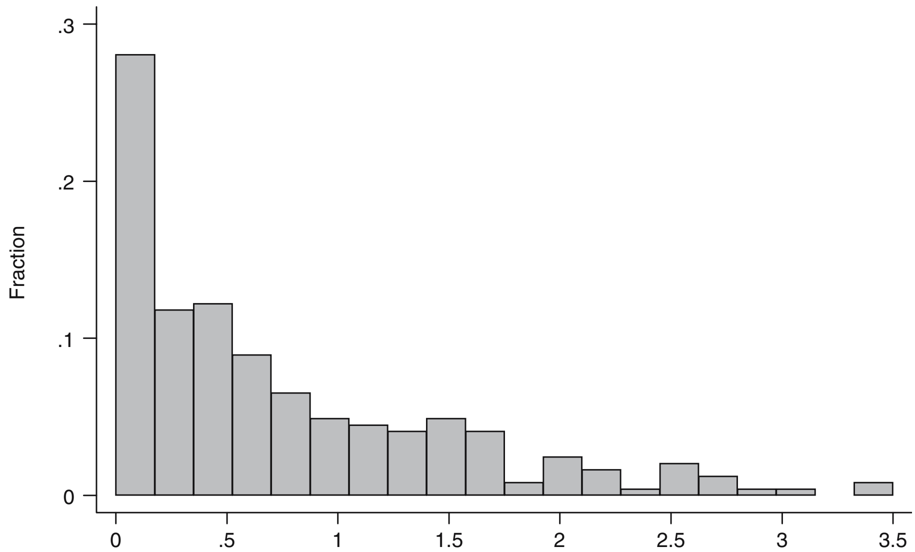

Figure 3. Direct size effect.

with large markets and poor countries merging with neighbors that exhibit superior steady-state determinants tend to gain. Large countries like the US tend to be indifferent to merging with small neighbors like Canada. The magnitudes of the gains and losses are commensurate with relative sizes and relative incomes.

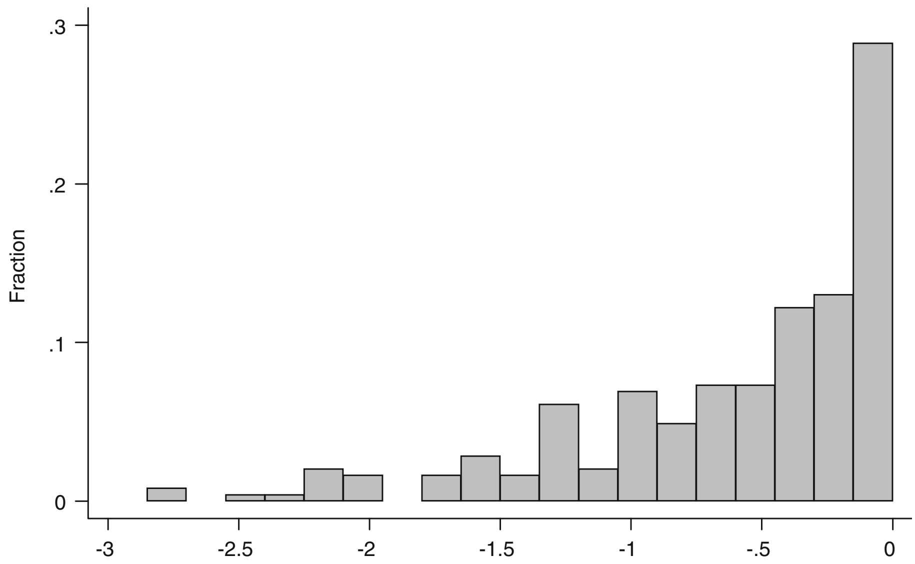

Figure 4. Indirect effect via openness reduction.

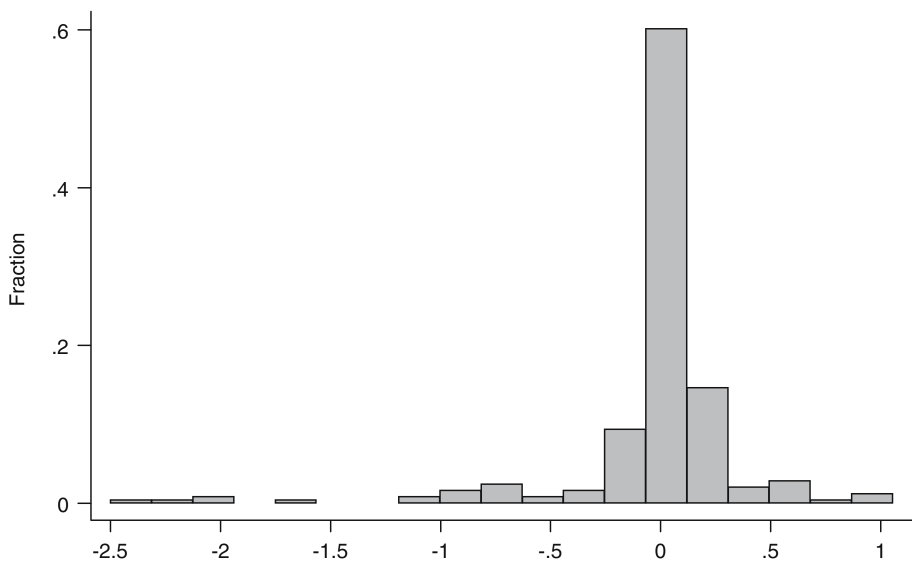

Figure 5. Interaction term effect.

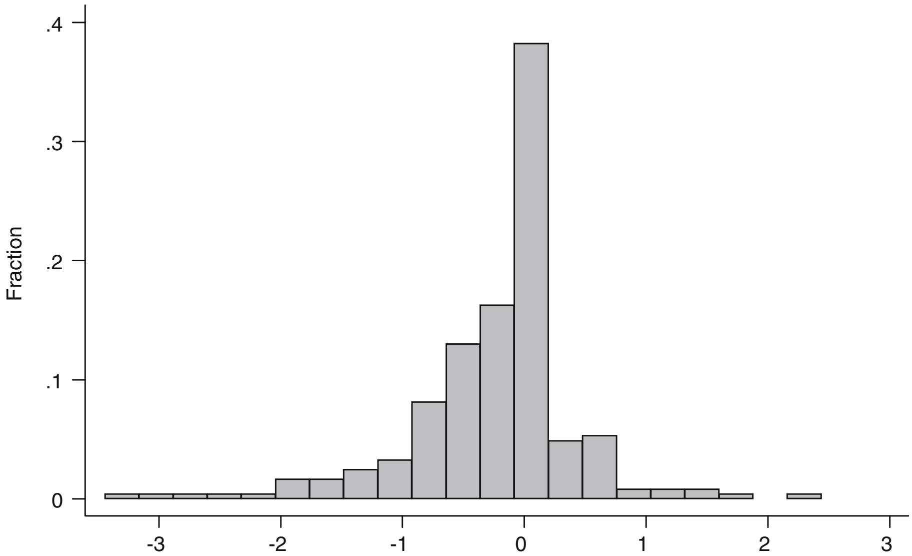

Figure 6. Steady-state determination effect.

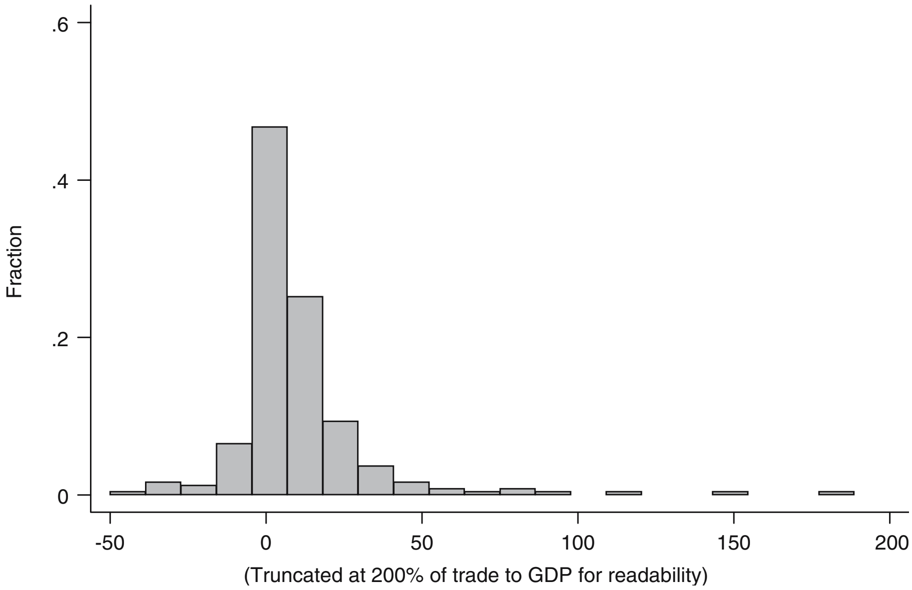

Figure 7. Openness equivalent—size merger.

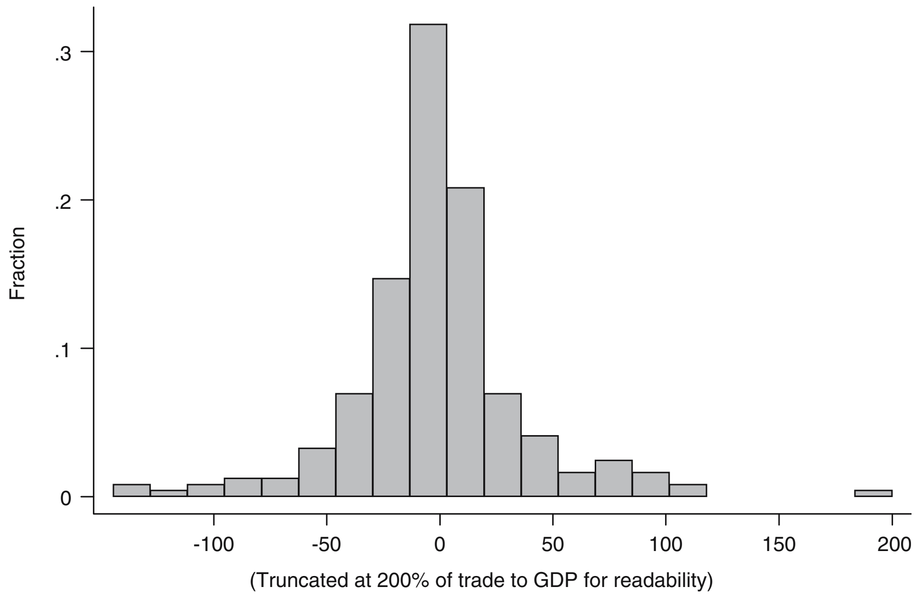

Figure 8. Openness equivalent—full integration.

To illustrate the results, we can examine more specifically the example of France and Italy (Table 7). The effect on France from merging with Italy would have been quite large and positive. We estimate that the total size effect would have resulted in a gain of 0.281 points of growth annually for France. To achieve a similar increase in growth via openness, France would have had to increase her trade to GDP ratio by 27.79 percentage points (for comparison, the average trade to GDP ratio of France over the sample period was 36%). Since Italy started with a lower level of per capita income than France in 1960, but has a higher estimated steady-state income level given its observed steady-state determinants, France would also have gained from the steady-state determination effect. This effect alone would have accounted for $\Delta G^m - \Delta G = 0.492$ additional points of growth.[47]

Turning to the effect on Italy from merging with France, it follows from what precedes that the steady-state determination effect would have been negative for Italy. Moreover, the positive size effect of a merger on Italian growth, equal to 0.237, would not have been sufficient to outweigh the negative steady-state determination effect. Under full integration, Italy would have lost -0.316 points of growth annually. A possible interpretation of these results is that, if France and

47 This is another way of saying that Italy was a faster growing country than France over the time period covered in the sample. In fact, the average *observed* annual growth rate of per capita income in Italy over the 1960–1989 period was 3.40%, while for France it was 2.94%. Our model *predicts* that, if France and Italy had merged, their unified growth rate over this period would have been 3.15% per year (under "full integration").

Table 7. An example: France and Italy (based on Tables 1 and 2, column (1) estimates).

Effect on (country a):	France	Italy
of merging with (country b):	Italy	France
Observed growth (country a)	2.936	3.404
Fitted growth (country a)	2.374	3.464
Direct effect of size	0.491	0.451
Indirect effect via openness	−0.396	−0.364
Effect via change in interaction term	0.186	0.149
Steady-state determination effect	0.492	−0.553
ΔG (“size merger”)	0.281	0.237
ΔG^m (“full integration”)	0.773	−0.316
Openness equivalent (“size merger”)	27.789	24.300
Openness equivalent (“full integration”)	76.423	−32.492
ΔG^e (“size merger” with residual effect)	0.294	0.265
ΔG^{me} (“full integration” with residual effect)	0.474	0.006
ΔSSY (steady-state level effect of a “size merger”) (%)	25.099	21.122
ΔSSY^m (steady-state level effect of “full integration”) (%)	57.011	−15.894

Notes: (a) ΔG (size merger) is the sum of the direct effect of size, the indirect effect via openness reduction, and the effect via the change in the interaction term
(b) ΔG^m (full integration) is the sum of ΔG (size merger) and the steady-state determination effect.
(c) The openness equivalent is the percentage point increase in the trade to GDP ratio needed to achieve a change in growth equivalent to merging with a neighbor (equation 37 in text).
(d) ΔG^e is ΔG plus the residual effect, as explained in Section 3.3 and Appendix 3.
(e) ΔG^{me} is ΔG^m plus the residual effect, as explained in Section 3.3 and Appendix 3.
(f) ΔSSY and ΔSSY^m are the steady-state level effects of a “size merger” and “full integration”, respectively.

Italy could somehow have achieved the more restrictive form of political integration implied by the “size merger” definition, i.e. a removal of the border without changes in national savings rates, human capital, etc., both could have benefited in terms of growth.

Interested readers can ponder upon the estimated effects of their favorite hypothetical political merger among the 246 examples listed in Table 8.

4.2.3. Residual Effects

Section 3.3 above outlined a methodology to include the residuals from the growth and openness regressions into our analysis. Table 8 (columns 9 and 10) presents estimates of ΔG^{me} and ΔG^e as in equations A.9 and A.10. The distribution of these effects is also displayed in Figures 9 and 10. Interestingly, the results do not change as much as expected given that the explained portions of growth and openness in the baseline regressions are only 60 and 50%, respectively. The simple correlation of ΔG with and without the residual effect is 0.737, while the

Table 8. Country-specific merger estimates.

Country a	Country b	a's Fitted growth	ΔG	ΔG^m	Direct	Indirect	Interact	ΔG^e	ΔG^{me}	$\Delta SSY(\%)$	$\Delta SSY^m(\%)$
1	2	3	4	5	6	7	8	9	10	11	12
Algeria	Mali	1.124	0.103	−0.178	0.232	−0.187	0.058	0.076	−0.392	9.209	−37.268
	Malta	1.124	0.015	0.061	0.035	−0.028	0.008	0.011	0.026	1.330	4.839
	Niger	1.124	0.087	−0.170	0.198	−0.160	0.049	0.064	−0.418	7.789	−32.517
	Tunisia	1.124	0.101	0.219	0.228	−0.184	0.057	0.074	0.417	9.015	8.828
Argentina	Bolivia	0.987	0.075	0.134	0.122	−0.099	0.051	0.089	0.136	6.658	0.786
	Brazil	0.987	0.779	1.340	1.107	−0.893	0.565	0.907	2.301	69.529	56.585
	Chile	0.987	0.143	0.110	0.230	−0.186	0.098	0.169	0.452	12.734	−0.268
	Paraguay	0.987	0.044	0.011	0.073	−0.059	0.030	0.053	0.157	3.943	−5.183
	Uruguay	0.987	0.047	−0.008	0.077	−0.062	0.032	0.056	0.110	4.167	−1.919
Australia	Fiji	2.291	0.021	−0.059	0.035	−0.028	0.015	0.018	−0.072	1.915	−7.981
	Indonesia	2.291	1.232	0.531	1.613	−1.301	0.920	1.065	0.781	109.960	−128.110
	New Zealand	2.291	0.089	−0.030	0.142	−0.115	0.061	0.074	−0.156	7.905	−2.256
	Papua New Guinea	2.291	0.082	−0.550	0.131	−0.106	0.056	0.068	−0.449	7.279	−63.385
	Sri Lanka	2.291	0.310	−0.587	0.473	−0.382	0.218	0.261	−0.882	27.626	−105.326
Austria	Germany, Fed. Rep.	4.128	0.403	−1.464	1.496	−1.207	0.114	0.460	−0.345	35.996	−108.690
	Italy	4.128	0.379	−0.535	1.436	−1.159	0.101	0.433	0.405	33.817	−58.122
	Switzerland	4.128	0.067	−0.404	0.408	−0.329	−0.012	0.083	−0.588	6.016	−5.444
Bangladesh	India	0.851	0.926	2.501	1.509	−1.217	0.634	1.273	0.579	82.667	204.027
Barbados	Colombia	4.310	−1.673	−2.428	3.081	−2.485	−2.268	−1.041	−1.337	−149.268	−261.782
	Trinidad & Tobago	4.310	−0.806	−2.249	1.100	−0.887	−1.019	−0.581	−2.359	−71.976	−138.866
	Venezuela	4.310	−1.549	−3.881	2.653	−2.140	−2.063	−1.006	−3.836	−138.287	−261.606
Belgium	France	3.051	0.199	−0.530	1.250	−1.008	−0.043	−0.217	−0.008	17.731	−42.409
	Germany, Fed. Rep.	3.051	0.225	−0.493	1.340	−1.081	−0.034	−0.221	−0.323	20.059	−28.483
	Netherlands	3.051	0.056	−0.025	0.585	−0.472	−0.058	−0.139	−0.407	4.971	3.541
Benin	Niger	−0.006	0.063	−0.012	0.661	−0.533	−0.064	0.190	0.160	5.653	−39.016
	Togo	−0.006	0.028	0.810	0.398	−0.321	−0.049	0.104	0.784	2.506	39.002
Bolivia	Argentina	1.951	0.578	−0.830	1.266	−1.021	0.333	0.522	−0.819	51.610	50.535
	Brazil	1.951	1.152	0.589	2.132	−1.720	0.739	1.057	1.719	102.778	95.070
Bolivia	Chile	1.951	0.320	−0.704	0.780	−0.629	0.169	0.285	0.042	28.560	8.816
	Paraguay	1.951	0.115	−0.230	0.314	−0.254	0.054	0.101	0.224	10.250	−19.665
	Peru	1.951	0.411	−0.162	0.962	−0.776	0.225	0.369	−0.640	36.723	30.274

Botswana	South Africa	1.341	0.666	−0.241	2.438	−1.967	0.195	−0.191	−3.395	59.460	117.516
	Zimbabwe	1.341	0.278	−0.182	1.509	−1.217	−0.014	−0.253	−4.036	24.780	39.610
Brazil	Argentina	2.488	0.149	−0.161	0.164	−0.132	0.118	0.132	−0.382	13.330	14.310
	Bolivia	2.488	0.041	0.052	0.045	−0.037	0.032	0.036	−0.009	3.658	3.047
	Colombia	2.488	0.136	0.114	0.149	−0.120	0.107	0.120	0.097	12.144	9.214
	Guyana	2.488	0.018	0.012	0.019	−0.016	0.014	0.015	−0.021	1.562	0.960
	Paraguay	2.488	0.029	0.017	0.032	−0.026	0.023	0.025	0.025	2.577	0.640
	Peru	2.488	0.094	0.070	0.104	−0.084	0.074	0.083	−0.161	8.404	7.790
	Uruguay	2.488	0.030	−0.029	0.033	−0.027	0.023	0.026	−0.027	2.664	1.431
	Venezuela	2.488	0.081	−0.115	0.089	−0.072	0.063	0.071	−0.232	7.202	10.716
Cameroon	Central Afr. Rep.	1.371	0.056	−0.317	0.183	−0.148	0.020	0.061	−0.769	4.957	−26.023
	Congo	1.371	0.040	−0.230	0.132	−0.107	0.014	0.044	−0.162	3.528	−9.715
Canada	U.S.A	1.777	1.367	1.288	1.608	−1.297	1.056	0.888	−0.738	121.956	143.482
Central Afr. Rep.	Cameroon	0.137	0.289	0.918	1.042	−0.841	0.087	0.194	2.466	25.775	74.775
	Congo	0.137	0.075	0.037	0.357	−0.288	0.006	0.043	1.064	6.736	23.269
	Zaire	0.137	0.578	0.650	1.699	−1.370	0.249	0.423	0.151	51.575	25.503
Chile	Argentina	0.991	0.377	0.107	0.866	−0.699	0.209	0.427	−0.646	33.621	43.039
	Bolivia	0.991	0.103	0.257	0.273	−0.220	0.050	0.119	−0.101	9.193	2.374
	Peru	0.991	0.253	0.481	0.617	−0.497	0.134	0.289	−0.525	22.615	24.426
Colombia	Barbados	1.880	0.011	0.002	0.022	−0.018	0.007	0.013	−0.001	1.021	1.057
	Brazil	1.880	0.740	0.723	1.178	−0.950	0.512	0.811	0.802	66.018	69.280
	Ecuador	1.880	0.102	0.131	0.192	−0.155	0.065	0.114	0.096	9.129	8.639
	Panama	1.880	0.033	−0.003	0.063	−0.051	0.021	0.036	−0.016	2.913	−0.694
	Peru	1.880	0.192	0.077	0.350	−0.282	0.124	0.213	−0.576	17.120	14.304
	Venezuela	1.880	0.164	−0.466	0.302	−0.244	0.106	0.183	−0.803	14.655	21.271
Congo	Cameroon	0.455	0.190	0.687	1.274	−1.027	−0.056	−0.223	−0.063	16.991	15.983
	Central Afr. Rep.	0.455	0.057	−0.282	0.640	−0.516	−0.067	−0.151	−2.072	5.053	−51.830
	Zaire	0.455	0.423	0.330	1.962	−1.583	0.044	−0.213	−2.862	37.755	−46.654
Costa Rica	Nicaragua	1.272	−0.033	−0.561	0.562	−0.454	−0.142	0.065	−1.446	−2.981	−64.023
Costa Rica	Panama	1.272	−0.031	−0.001	0.445	−0.359	−0.118	0.046	−0.077	−2.807	−12.696
Cyprus	Greece	4.934	−0.524	−1.323	1.870	−1.509	−0.886	−0.217	−0.647	−46.761	−115.560
	Israel	4.934	−0.423	−2.252	1.241	−1.001	−0.663	−0.219	−1.346	−37.718	−156.765
	Turkey	4.934	−0.533	−2.165	2.812	−2.268	−1.077	−0.073	−2.068	−47.599	−215.453
Denmark	Germany, Fed. Rep.	2.198	0.261	0.236	1.747	−1.409	−0.077	0.543	0.171	23.294	18.404
	Iceland	2.198	0.000	−0.267	0.029	−0.023	−0.006	0.004	−0.255	−0.040	−24.818

Table 8. Continued.

Country *a*	Country *b*	*a*'s Fitted growth	ΔG	ΔG^m	Direct	Indirect	Interact	ΔG^e	ΔG^{me}	$\Delta SSY(\%)$	$\Delta SSY^m(\%)$
1	2	3	4	5	6	7	8	9	10	11	12
Dominican Rep.	Haiti	2.074	0.018	−0.538	0.486	−0.392	−0.076	0.159	−1.368	1.615	−61.046
	Jamaica	2.074	0.004	−0.048	0.247	−0.199	−0.044	0.075	−0.495	0.314	10.464
Ecuador	Colombia	2.127	0.310	−0.117	1.017	−0.820	0.113	0.444	0.173	27.662	0.758
	Peru	2.127	0.226	−0.273	0.796	−0.642	0.072	0.331	−1.188	20.148	−1.150
El Salvador	Guatemala	0.841	−0.024	−0.168	0.646	−0.521	−0.149	0.159	0.000	−2.156	−5.590
	Honduras	0.841	−0.025	−0.055	0.413	−0.333	−0.105	0.093	−0.056	−2.204	−17.273
Fiji	Australia	2.621	−0.430	−0.388	2.191	−1.767	−0.853	−0.171	0.108	−38.344	93.211
	New Zealand	2.621	−0.359	−0.653	1.256	−1.013	−0.602	−0.211	−0.848	−32.053	63.566
Finland	Norway	2.486	0.090	0.201	0.413	−0.333	0.010	0.118	−0.140	8.018	20.619
	Sweden	2.486	0.165	−0.414	0.678	−0.547	0.034	0.212	−0.725	14.727	−12.821
France	Belgium	2.374	0.063	0.147	0.118	−0.095	0.041	0.067	−0.026	5.663	12.174
	Germany, Fed. Rep.	2.374	0.303	0.245	0.526	−0.425	0.202	0.317	0.020	27.083	28.662
	Italy	2.374	0.281	0.773	0.491	−0.396	0.186	0.294	0.474	25.099	57.011
	Spain	2.374	0.197	0.470	0.352	−0.284	0.129	0.206	0.509	17.566	21.476
	Switzerland	2.374	0.042	0.142	0.078	−0.063	0.026	0.044	−0.072	3.706	18.897
	United Kingdom	2.374	0.286	−0.364	0.498	−0.402	0.189	0.299	−0.140	25.496	−23.711
Germany, Fed. Rep.	Austria	2.432	0.039	0.231	0.079	−0.064	0.023	0.038	0.099	3.438	18.175
	Belgium	2.432	0.049	0.125	0.101	−0.082	0.030	0.049	0.026	4.409	8.848
	Denmark	2.432	0.026	0.001	0.054	−0.044	0.016	0.026	0.029	2.329	0.341
	France	2.432	0.217	0.187	0.419	−0.338	0.136	0.213	0.387	19.352	11.411
	Netherlands	2.432	0.066	0.180	0.135	−0.109	0.040	0.065	0.010	5.924	14.802
	Switzerland	2.432	0.032	0.125	0.066	−0.054	0.019	0.032	−0.022	2.865	14.891
Ghana	Togo	1.545	0.044	0.091	0.157	−0.126	0.013	0.076	0.308	3.899	−3.164
Greece	Cyprus	3.605	0.009	0.006	0.046	−0.037	0.000	0.019	−0.009	0.760	0.345
	Turkey	3.605	0.324	−0.634	1.121	−0.904	0.108	0.577	−1.059	28.947	−75.536
	Yugoslavia	3.605	0.211	0.321	0.811	−0.654	0.054	0.393	−0.416	18.797	22.824
Guatemala	El Salvador	0.815	0.053	−0.142	0.360	−0.290	−0.017	0.155	−0.029	4.692	−18.431
	Honduras	0.815	0.043	0.046	0.304	−0.245	−0.016	0.129	0.039	3.813	−9.188
	Mexico	0.815	0.436	1.022	1.629	−1.314	0.121	0.900	1.416	38.943	140.856
Guinea Bissau	Senegal	2.243	−0.141	−2.056	1.444	−1.165	−0.420	0.472	−0.780	−12.559	−117.343

Guyana	Brazil	1.286	0.726	1.214	3.410	−2.750	0.067	−0.846	4.220	64.789	119.398
	Venezuela	1.286	0.150	−0.882	1.981	−1.598	−0.233	−0.764	0.851	13.365	53.913
Haiti	Dominican Rep.	1.288	−0.008	0.247	0.477	−0.385	−0.100	0.207	1.433	−0.727	34.801
	Jamaica	1.288	−0.010	0.156	0.237	−0.191	−0.055	0.097	0.315	−0.849	37.999
Honduras	El Salvador	1.314	0.049	−0.527	0.576	−0.465	−0.062	0.108	−0.320	4.396	−27.723
	Guatemala	1.314	0.077	−0.452	0.753	−0.607	−0.068	0.153	−0.197	6.879	−6.797
	Nicaragua	1.314	0.029	−0.472	0.414	−0.334	−0.051	0.071	−0.891	2.580	−20.166
Hong Kong	Singapore	5.622	−0.098	−0.251	0.282	−0.228	−0.153	−0.288	−0.878	−8.755	−32.005
Iceland	Denmark	3.396	−0.363	−1.465	2.170	−1.750	−0.783	0.002	−1.270	−32.409	−100.837
	Norway	3.396	−0.367	−0.441	2.020	−1.629	−0.758	−0.027	−0.227	−32.768	−27.661
	Sweden	3.396	−0.340	−1.553	2.489	−2.008	−0.822	0.079	−1.189	−30.363	−96.927
India	Bangladesh	3.424	0.097	−0.072	0.092	−0.074	0.079	0.087	0.199	8.652	−3.850
	Pakistan	3.424	0.092	0.157	0.087	−0.070	0.075	0.082	0.329	8.170	12.410
	Sri Lanka	3.424	0.029	0.028	0.027	−0.022	0.023	0.026	0.050	2.561	3.923
Indonesia	Australia	3.392	0.052	−0.569	0.079	−0.064	0.037	0.048	−0.616	4.658	23.824
	Malaysia	3.392	0.048	0.051	0.072	−0.058	0.034	0.044	0.055	4.259	13.995
	Papua New Guinea	3.392	0.017	−0.046	0.026	−0.021	0.012	0.016	−0.045	1.533	−2.267
	Philippines	3.392	0.135	−0.069	0.201	−0.162	0.096	0.125	−0.329	12.075	10.221
	Sri Lanka	3.392	0.052	−0.049	0.078	−0.063	0.037	0.048	−0.129	4.614	4.570
Iran	Pakistan	1.219	0.448	1.015	0.801	−0.646	0.293	0.467	1.632	39.960	12.156
	Turkey	1.219	0.300	1.072	0.559	−0.451	0.192	0.313	1.509	26.740	65.722
Ireland	United Kingdom	2.333	0.272	−0.982	1.986	−1.602	−0.112	−0.010	−0.950	24.301	−18.009
Israel	Cyprus	2.515	−0.017	0.168	0.137	−0.111	−0.044	0.007	0.058	−1.539	5.720
	Jordan	2.515	−0.037	−0.721	0.360	−0.291	−0.107	0.027	−0.357	−3.347	−99.526
	Syria	2.515	−0.049	−0.865	0.811	−0.654	−0.206	0.096	−0.350	−4.398	−124.013
Italy	Austria	3.464	0.043	0.129	0.087	−0.071	0.026	0.048	0.014	3.820	13.090
	France	3.464	0.237	−0.316	0.451	−0.364	0.149	0.265	0.006	21.122	−15.894
	Malta	3.464	0.002	0.001	0.005	−0.004	0.001	0.003	−0.004	0.210	−0.389
Italy	Switzerland	3.464	0.036	0.008	0.073	−0.059	0.022	0.040	−0.128	3.187	10.499
Jamaica	Dominican Rep.	2.698	−0.165	−0.672	0.848	−0.684	−0.329	−0.052	0.723	−14.750	−84.722
	Haiti	2.698	−0.165	−1.254	0.847	−0.683	−0.329	−0.052	−1.268	−14.747	−153.034
Japan	Korea	5.361	0.108	0.119	0.185	−0.149	0.072	0.139	0.353	9.645	−4.978
	Philippines	5.361	0.129	−0.759	0.220	−0.177	0.087	0.166	−0.934	11.530	−82.917
	Taiwan	5.361	0.053	−0.070	0.092	−0.074	0.035	0.069	0.156	4.740	−12.355

Table 8. Continued.

Country *a*	Country *b*	*a*'s Fitted growth	ΔG	ΔG^m	Direct	Indirect	Interact	ΔG^e	ΔG^{me}	$\Delta SSY(\%)$	$\Delta SSY^m(\%)$
1	2	3	4	5	6	7	8	9	10	11	12
Jordan	Israel	1.634	0.016	0.159	0.636	−0.513	−0.107	−0.041	−0.356	1.434	88.681
	Syria	1.634	0.062	−0.111	1.010	−0.814	−0.133	−0.029	−0.294	5.515	13.099
Kenya	Uganda	1.385	0.184	−0.323	0.426	−0.343	0.102	0.121	−0.492	16.459	−33.066
Korea	Japan	5.788	0.425	−0.308	0.990	−0.798	0.234	0.459	−0.934	37.952	75.304
	Taiwan	5.788	0.096	−0.344	0.265	−0.214	0.044	0.105	−0.068	8.528	−19.555
Lesotho	South Africa	2.713	0.035	−1.556	2.122	−1.712	−0.376	−0.440	−2.612	3.086	51.695
Malawi	Zambia	1.396	0.085	−0.396	0.463	−0.374	−0.004	0.102	−1.226	7.616	19.143
Malaysia	Indonesia	3.161	0.749	0.282	1.690	−1.363	0.422	0.117	−0.427	66.863	−45.458
	Singapore	3.161	0.037	0.215	0.126	−0.102	0.013	−0.010	−0.226	3.300	21.953
	Thailand	3.161	0.380	−0.371	1.006	−0.812	0.185	0.004	0.103	33.894	−62.738
Mali	Algeria	0.260	0.414	0.685	0.904	−0.729	0.239	0.422	1.202	36.942	156.763
	Niger	0.260	0.171	0.043	0.417	−0.336	0.091	0.175	−0.079	15.290	3.572
	Senegal	0.260	0.174	−0.192	0.422	−0.341	0.092	0.177	−0.025	15.501	19.067
Malta	Algeria	6.150	−1.523	−4.965	2.614	−2.108	−2.028	−1.677	−3.673	−135.894	−421.068
	Italy	6.150	−1.733	−2.685	3.452	−2.784	−2.400	−1.937	−2.026	−154.651	−120.031
	Tunisia	6.150	−1.257	−4.330	1.942	−1.566	−1.632	−1.371	−2.282	−112.143	−406.793
Mexico	Guatemala	1.885	0.057	−0.048	0.084	−0.067	0.041	0.059	−0.038	5.075	−8.159
	U.S.A	1.885	0.833	1.038	1.074	−0.866	0.625	0.865	−0.041	74.304	204.256
Netherlands	Belgium	3.094	0.051	−0.068	0.373	−0.301	−0.021	−0.020	−0.002	4.588	−10.388
	Germany, Fed. Rep.	3.094	0.248	−0.481	1.162	−0.938	0.023	0.025	0.066	22.147	−36.458
	United Kingdom	3.094	0.234	−1.410	1.119	−0.902	0.018	0.019	−0.191	20.893	−116.219
New Zealand	Australia	2.196	0.204	0.065	1.164	−0.939	−0.021	0.362	0.727	18.251	3.998
	Fiji	2.196	0.009	−0.228	0.122	−0.098	−0.014	0.026	−0.146	0.821	−31.372
Nicaragua	Costa Rica	0.631	0.019	0.080	0.426	−0.343	−0.063	0.073	0.939	1.693	19.823
	Honduras	0.631	0.035	0.211	0.584	−0.471	−0.078	0.109	0.882	3.108	−2.783
Niger	Algeria	0.231	0.457	0.723	1.015	−0.819	0.261	0.471	1.488	40.765	164.683
Niger	Benin	0.231	0.136	−0.249	0.351	−0.283	0.068	0.141	−0.273	12.117	12.430
	Mali	0.231	0.228	0.072	0.562	−0.453	0.120	0.236	0.234	20.387	6.741
Norway	Finland	3.044	0.103	−0.357	0.534	−0.430	−0.001	−0.018	−0.035	9.152	−35.034
	Iceland	3.044	0.005	−0.089	0.036	−0.029	−0.002	−0.003	−0.090	0.470	− 8.468
	Sweden	3.044	0.162	−0.824	0.757	−0.611	0.015	−0.009	−0.783	14.442	−52.154

Pakistan	India	2.728	1.223	0.853	1.558	−1.257	0.921	1.213	−0.726	109.106	92.826
	Iran	2.728	0.187	−0.494	0.282	−0.228	0.132	0.185	−0.775	16.674	30.518
Panama	Colombia	1.766	0.169	0.111	1.838	−1.482	−0.187	0.155	0.324	15.050	16.157
	Costa Rica	1.766	−0.018	−0.495	0.535	−0.431	−0.121	−0.022	−0.323	−1.594	−28.217
Papua New Guinea	Australia	−0.005	0.293	1.746	1.226	−0.989	0.056	0.099	0.981	26.192	325.630
	Indonesia	−0.005	1.000	3.350	2.655	−2.142	0.487	0.578	2.782	89.271	234.815
Paraguay	Argentina	1.362	0.500	−0.363	1.620	−1.307	0.186	0.809	−1.370	44.581	94.667
	Bolivia	1.362	0.159	0.359	0.718	−0.579	0.020	0.296	−0.348	14.200	30.436
	Brazil	1.362	0.997	1.143	2.522	−2.035	0.509	1.478	1.181	88.935	142.764
Peru	Bolivia	1.660	0.102	0.129	0.210	−0.169	0.061	0.105	0.274	9.089	−0.240
	Brazil	1.660	0.867	0.898	1.439	−1.160	0.589	0.886	2.482	77.403	69.299
	Chile	1.660	0.186	−0.188	0.372	−0.300	0.114	0.191	0.532	16.617	0.354
	Colombia	1.660	0.346	0.297	0.656	−0.529	0.219	0.355	1.361	30.892	15.746
	Ecuador	1.660	0.136	0.194	0.277	−0.224	0.083	0.140	0.673	12.153	8.172
Philippines	Indonesia	2.301	0.521	1.021	0.977	−0.788	0.332	0.550	1.828	46.470	50.146
	Japan	2.301	0.470	2.301	0.895	−0.722	0.297	0.497	2.889	41.957	286.007
Portugal	Spain	2.831	0.266	0.304	1.050	−0.847	0.063	0.317	−0.399	23.751	68.910
Rwanda	Uganda	0.890	0.043	−0.395	0.871	−0.703	−0.126	0.461	−0.862	3.815	−27.551
	Zaire	0.890	0.113	−0.077	1.280	−1.032	−0.134	0.728	−1.226	10.092	−14.783
Senegal	Guinea Bissau	0.032	0.016	0.156	0.102	−0.082	−0.003	0.012	0.060	1.462	6.680
	Mali	0.032	0.112	0.036	0.550	−0.444	0.006	0.089	−0.183	9.989	−27.679
	The Gambia	0.032	0.014	0.074	0.086	−0.070	−0.003	0.010	−0.031	1.223	2.475
Singapore	Hong Kong	5.955	−0.313	−0.584	0.761	−0.614	−0.460	−1.675	−1.049	−27.943	−31.349
	Malaysia	5.955	−0.465	−2.579	1.291	−1.041	−0.715	−2.775	−2.661	−41.522	−242.860
	Thailand	5.955	−0.587	−3.269	2.027	−1.635	−0.979	−4.214	−2.409	−52.401	−343.783
South Africa	Botswana	1.138	0.019	−0.038	0.035	−0.028	0.012	0.012	0.023	1.666	−5.351
	Lesotho	1.138	0.025	0.019	0.047	−0.038	0.016	0.016	0.037	2.203	−2.360
South Africa	Swaziland	1.138	0.015	−0.008	0.028	−0.023	0.009	0.009	−0.009	1.331	−1.400
	Zimbabwe	1.138	0.085	0.064	0.157	−0.127	0.055	0.054	−0.182	7.585	−3.887
Spain	France	3.156	0.333	−0.312	0.617	−0.498	0.214	0.393	−0.295	29.710	13.967
	Portugal	3.156	0.082	−0.021	0.164	−0.133	0.050	0.098	0.198	7.275	−11.475
Sri Lanka	Australia	2.270	0.092	−0.565	0.482	−0.389	−0.002	0.095	−0.312	8.182	78.756
	India	2.270	1.031	1.182	2.612	−2.107	0.526	1.048	0.038	91.987	57.212
	Indonesia	2.270	0.486	1.073	1.622	−1.308	0.172	0.497	1.837	43.352	36.718
Swaziland	South Africa	1.088	−0.287	0.042	2.734	−2.205	−0.816	−1.132	−1.018	−25.599	59.321

Table 8. Continued.

Country a	Country b	a's Fitted growth	ΔG	ΔG^m	Direct	Indirect	Interact	ΔG^e	ΔG^{me}	$\Delta SSY(\%)$	$\Delta SSY^m(\%)$
1	2	3	4	5	6	7	8	9	10	11	12
Sweden	Finland	1.865	0.092	0.206	0.311	−0.251	0.031	0.090	0.412	8.171	6.416
	Iceland	1.865	0.005	−0.023	0.018	−0.015	0.001	0.005	−0.022	0.429	−2.844
	Norway	1.865	0.078	0.354	0.269	−0.217	0.026	0.076	0.248	6.975	22.735
Switzerland	Austria	3.486	0.043	0.238	0.539	−0.435	−0.061	0.092	0.529	3.856	−8.557
	France	3.486	0.264	−0.971	1.518	−1.224	−0.029	0.403	0.968	23.597	−128.333
	Germany, Fed. Rep.	3.486	0.296	−0.929	1.614	−1.302	−0.016	0.443	0.651	26.413	−115.087
	Italy	3.486	0.276	−0.014	1.553	−1.252	−0.025	0.417	1.380	24.599	−63.826
Syria	Israel	1.575	0.061	0.075	0.279	−0.225	0.008	0.102	−0.051	5.482	39.063
	Jordan	1.575	0.043	−0.052	0.202	−0.163	0.004	0.073	0.004	3.838	−12.032
	Turkey	1.575	0.406	1.061	1.281	−1.033	0.158	0.594	−0.220	36.215	97.229
Taiwan	Japan	4.608	0.347	0.683	1.429	−1.153	0.071	0.339	−0.815	30.963	140.384
	Korea	4.608	0.145	0.836	0.798	−0.643	−0.009	0.141	0.249	12.958	52.901
Thailand	Malaysia	2.573	0.104	0.217	0.197	−0.159	0.066	0.091	−0.053	9.317	30.663
	Singapore	2.573	0.028	0.113	0.053	−0.043	0.017	0.024	−0.130	2.454	14.431
The Gambia	Senegal	2.044	−0.398	−1.938	1.576	−1.271	−0.703	−0.125	−0.755	−35.532	−121.751
Togo	Benin	2.597	0.002	−1.794	0.592	−0.477	−0.112	−0.070	−1.730	0.205	−83.591
	Ghana	2.597	0.065	−0.960	1.145	−0.923	−0.156	−0.074	−1.887	5.827	−8.000
Trinidad & Tobago	Barbados	2.034	−0.069	0.027	0.155	−0.125	−0.099	−0.030	0.149	−6.135	−10.413
Tunisia	Algeria	1.727	0.228	−0.385	0.916	−0.739	0.051	0.204	−1.039	20.340	−0.229
	Malta	1.727	0.009	0.093	0.051	−0.041	−0.001	0.007	−0.039	0.760	10.058
Turkey	Cyprus	2.742	0.014	0.028	0.025	−0.020	0.009	0.016	0.036	1.225	2.993
	Greece	2.742	0.089	0.229	0.159	−0.128	0.058	0.107	0.408	7.947	27.006
	Iran	2.742	0.250	−0.451	0.426	−0.344	0.168	0.298	−0.759	22.355	−10.525
	Syria	2.742	0.073	−0.106	0.130	−0.105	0.048	0.087	0.182	6.486	−9.886
U.S.A	Canada	2.995	0.069	0.069	0.070	−0.056	0.055	0.060	0.221	6.137	3.764
	Mexico	2.995	0.162	−0.072	0.163	−0.132	0.131	0.141	0.203	14.469	−19.768
Uganda	Kenya	0.426	0.203	0.636	0.580	−0.468	0.091	0.370	0.938	18.092	62.210
	Rwanda	0.426	0.080	0.069	0.252	−0.203	0.031	0.153	0.498	7.145	3.105
	Zaire	0.426	0.298	0.379	0.803	−0.647	0.143	0.530	0.051	26.588	20.015

United Kingdom	France	1.308	0.209	0.702	0.444	−0.358	0.123	0.211	0.509	18.670	55.590
	Ireland	1.308	0.016	0.042	0.038	−0.030	0.009	0.016	0.025	1.447	1.118
	Netherlands	1.308	0.064	0.376	0.145	−0.117	0.036	0.065	0.035	5.731	31.593
Uruguay	Argentina	0.639	0.311	0.341	1.563	−1.261	0.008	0.824	−0.129	27.727	40.951
	Brazil	0.639	0.702	1.820	2.462	−1.986	0.226	1.511	2.417	62.674	86.575
Venezuela	Barbados	0.393	0.013	0.036	0.042	−0.034	0.005	0.015	0.049	1.126	1.382
	Brazil	0.393	0.700	1.980	1.565	−1.262	0.397	0.806	3.021	62.479	70.930
	Colombia	0.393	0.276	1.021	0.749	−0.604	0.132	0.327	1.745	24.669	21.418
	Guyana	0.393	0.020	0.011	0.066	−0.053	0.007	0.025	−0.137	1.789	−4.311
Yugoslavia	Greece	4.050	0.073	−0.124	0.247	−0.199	0.025	0.109	0.311	6.508	−8.321
Zaire	Central Afr. Rep.	0.810	0.047	−0.023	0.078	−0.063	0.032	0.043	0.004	4.162	1.888
	Congo	0.810	0.035	−0.025	0.059	−0.048	0.024	0.032	0.127	3.150	4.830
	Rwanda	0.810	0.081	0.003	0.135	−0.109	0.055	0.075	0.325	7.269	1.737
	Uganda	0.810	0.171	−0.005	0.277	−0.224	0.117	0.157	0.241	15.267	5.880
	Zambia	0.810	0.089	0.097	0.148	−0.119	0.061	0.082	−0.076	7.963	23.515
Zambia	Malawi	1.000	0.178	−0.001	0.521	−0.420	0.077	−0.008	0.731	15.904	−38.779
	Zaire	1.000	0.496	−0.093	1.215	−0.980	0.261	0.063	0.273	44.304	−61.472
	Zimbabwe	1.000	0.197	0.175	0.567	−0.458	0.087	−0.006	0.672	17.541	16.938
Zimbabwe	Botswana	1.316	0.028	−0.157	0.107	−0.087	0.008	0.017	0.251	2.543	−19.579
	South Africa	1.316	0.424	−0.114	1.158	−0.934	0.200	0.298	0.687	37.870	59.791
	Zambia	1.316	0.127	−0.140	0.429	−0.346	0.044	0.080	−0.755	11.351	−13.648

(a) ΔG (size merger) is the sum of the direct effect of size, the indirect effect via openness reduction, and the effect via the change in the interaction term.
(b) ΔG^m (full integration) is the sum of ΔG (size merger) and the steady-state determination effect.
(c) ΔG^e is ΔG plus the residual effect, as explained in Section 3.3 and Appendix 3.
(d) ΔG^{me} is ΔG^m plus the residual effect, as explained in Section 3.3 and Appendix 3.
(e) ΔSSY and ΔSSY^m are the steady-state level effects of a "size merger" and "full integration", respectively.

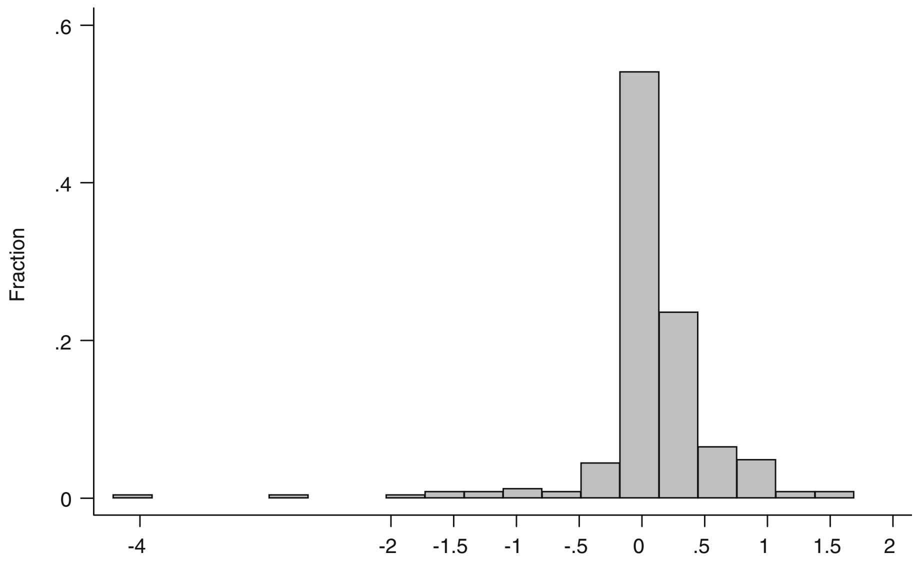

Figure 9. Effect of size merger on growth—with residual.

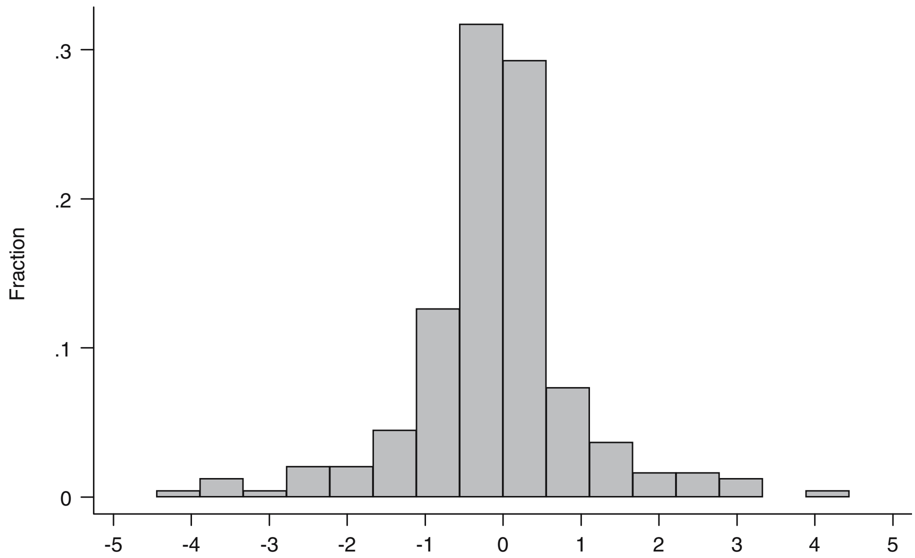

Figure 10. Effect of full integration on growth—with residual.

corresponding figure for ΔG^m is 0.640. Out of 246 mergers, accounting for the residual leads to a change in the sign of the effect in 31 cases for ΔG (12.6% of the cases) and 75 cases for ΔG^m (30.1%).[48]

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48 In general, accounting for the residual effect has a much smaller effect on estimates of pure size mergers than it does on estimates of full integration, because the former only involves the

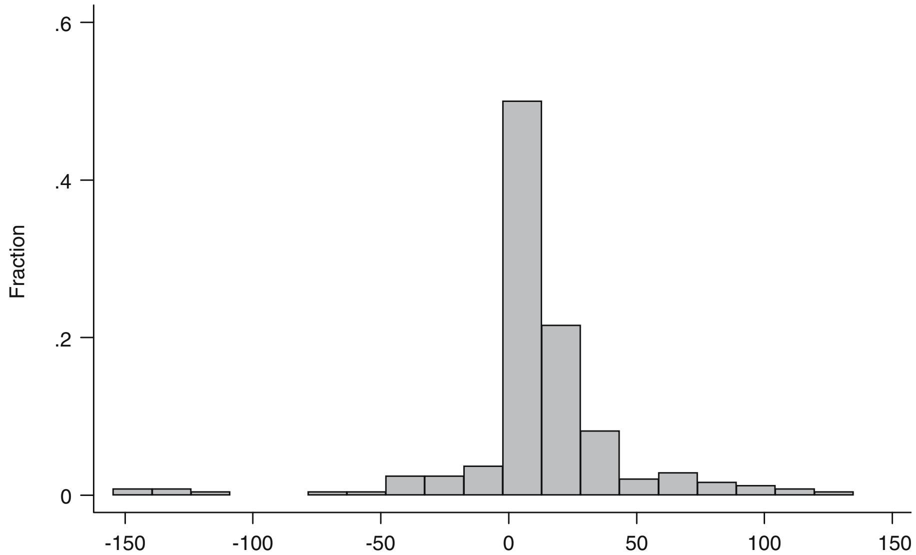

Figure 11. Effect of size merger on steady-state income (%).

Again, the case of France and Italy is illustrative (Table 7). Since France's explained annual growth falls short of its observed growth by 0.56 points, while Italy's observed and explained growth are about equal, accounting for the residual in the merger experiment is now slightly beneficial to Italy—which would have gained both under a size merger and full integration.

4.2.4. *Effects on Steady-State Income Levels*

Columns 11 and 12 of Table 8 presents, for each country pair, the estimated effect of a merger on the steady-state income level of country a, while the last row of Table 6 presents summary statistics for the steady-state level effects (the distribution of these level effects is displayed in Figures 11 and 12 for a size merger and full integration, respectively). On average, size mergers would raise a country's steady-state income level by 10.98 percentage points and full integration would reduce it by 2.07 percentage points. These averages reflect the generally positive effect of a size merger and the ambiguous effect of full integration. However, they again mask considerable case-specific differences. The effect of full integration ranges from -421.07 percentage points (the effect on Malta from merging with Algeria—a small rich country merging with a relatively large poor country) to 325.63 percentage points (the effect on Papua New Guinea from merging with

residual from the openness regression (multiplied by the coefficient on openness in the growth regression), while the latter involves the population weighted average of the residual from the growth regression. See equations (A.9) and (A.10).

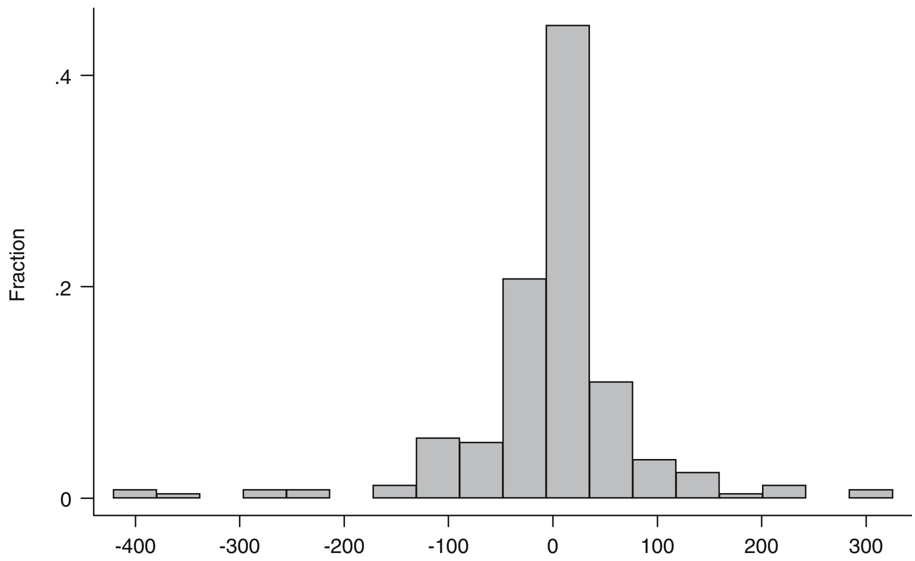

Figure 12. Effect of full integration on steady-state income (%).

Australia—a small poor country merging with a rich country with five times its population). Logically, large effects such as these are found in cases where neighbors have very different sizes and income determinants.

More moderate effects are found in regions that are homogeneous in terms of income and size. For example, Table 7 shows that a size merger between France and Italy would have raised both countries' steady-state income levels by 25.1 percentage points for France and 21.12 points for Italy. Full integration would have reduced Italy's steady-state income by 15.89 percentage points. This partly reflects compounding the negative growth effect on Italy of full integration with France, as discussed earlier. The merger would raise France's steady-state income by 57.01 points, reflecting Italy's superior steady-state determinants.

4.3. Convergent Interests in Political Integration

An interesting application of our framework is to examine pairs of countries in which *both would have* benefited from merging politically. As suggested above, it is much easier for two countries to have convergent interests in a size merger than in full integration, because the effect of the former is far more likely to be positive for any given country. Out of the 123 political mergers we considered in this paper, 94 entail growth gains for both country *a* and country *b* based on a *size merger alone*, and only six cases did the trade reduction effect dominate in both countries—so that both would have experienced reduced growth under a merger. These cases pertain to pairs of very small and already open countries, such as Singapore and Hong Kong or Jamaica and Haiti. Taken at face value, these results suggest that it would be mutually beneficial for most country pairs to grant each

Table 9. Pairs of countries that would both have gained from full political integration ($\Delta G^m > 0$ for both countries).

Argentina	Chile
Bolivia	Brazil
Brazil	Colombia
Brazil	Guyana
Brazil	Paraguay
Brazil	Peru
Canada	U.S.A
Colombia	Peru
Denmark	Federal Republic of Germany
France	Federal Republic of Germany
India	Pakistan
India	Sri Lanka
Indonesia	Malaysia
Mali	Niger

other access to their markets, though the reduction of formal and informal barriers to trade in goods.

An interesting question that arises from these results is whether the extent of the border effects can be used to predict the emergence of regional trading arrangements (RTAs). The literature on RTAs has so far focused on their effects on trade *volumes*, not growth (Viner, 1950; Vousden, 1990). In principle, one could look at the extent of the growth effects of "size mergers" and predict that pairs with large mutual gains will enter into RTAs. However, the potential effects on economic growth of granting reciprocal market access are not the only reason countries enter into RTAs: there are a myriad political factors, lying beyond the scope of this paper, affecting their emergence. Moreover, one limitation of our approach is that we only consider mergers between two countries, whereas proposed RTAs often involve more than two countries (our methodology could be easily extended to consider the growth impact of such arrangements). For these reasons, we would urge caution in using our results to predict the emergence of trade blocks, though this is a promising avenue for future research.

In contrast to size mergers, in only 14 cases would both countries in a merging pair have benefited (in terms of economic growth) from full integration.[49] These pairs are listed in Table 9. Salient examples include Argentina and Chile, France and Germany, Canada and the US, India and Pakistan, as well as several country pairs involving Brazil. Of course, many more cases would entail a winner and a loser among the merging pair. Ninety two cases out of 123 entail exactly one country that would have gained from full political integration, while the other would have lost, and in the remaining 17 cases both countries would have lost. The conclusion is that, in 109 of the 123 cases we considered, borders shield at least one country from the other's slower growth.

49 All of these pairs are also composed of countries that would both have benefited from size mergers with each other.

An implication of these observations is that, when unions of country pairs are considered, it may be easier to gain mutual support for a form of political integration that shields countries from having to share their Z_{at} and W_{at} variables but focuses instead on taking advantage of scale effects, through the formation of free trade areas and the reduction of physical trading costs.

5. Conclusion

This paper provides a theoretical framework to understand the relationship between political borders and growth. We suggested that, whenever scale effects are present, political borders affect steady-state per capita income levels and transitional growth rates by reducing the extent of the market. We also pointed out that, in a world of more than two countries, the removal of only one border will result in trade reduction from the merging countries vis-à-vis the rest of the world, with correspondingly adverse effects on growth and income. We examined formal conditions under which the extent of the market effect dominates the trade reduction effect, and discussed situations in which countries might differ in more that just size and openness levels.

We then derived an empirical specification directly from the theoretical model, and found strong empirical support for the predictions of our theory. Baseline parameter estimates from this empirical model were used to estimate, for specific countries, the growth effects of merging with another country. We have applied this framework to 123 pairs of adjacent countries and proximate islands. We found that full political integration with a neighbor would have a slight *negative* impact on the average country. This type of political integration, which entails full averaging of steady-state determinants across merging pairs, generally involves a winner and a loser—in only 14 of 123 cases would a merger have raised both country's growth rate. In contrast, countries would in general benefit from expanding the extent of their markets through deep economic integration with their neighbors, as shown by the prevalence of positive estimated effects under "size mergers". A limited form of integration that entails access to markets and a reduction of trade costs, to take advantage of scale effects, seems more likely to benefit both countries in a pair than a form of integration that results in uniform growth determinants across country pairs.

Our framework can be extended in several directions. First, we have limited our investigation to hypothetical mergers involving only two countries. However, our framework is readily applicable to studying the growth effects of more than one political border. We could apply our methodology, for example, to the removal of all borders within Europe, in order to study the growth implications of proposals for European political integration. Our results for France and Germany suggest that both would have benefited, in terms of growth, from merging politically. Whether European countries would have benefited from the removal of all intra-European borders is an open and equally interesting question.

Second, our estimation method focuses exclusively on growth and income levels. There are obviously many other reasons, beyond growth, why countries would want to merge or stay separate. We can interpret our estimates of the growth effects of borders, whenever they are negative, as the amount of growth a country is willing to forego in order to avoid the noneconomic costs of sharing a single polity with a neighbor. These may include increases in cultural, ethnic, religious or linguistic heterogeneity. Future work could relate changes in heterogeneity resulting from political integration to the magnitude of the growth costs or benefits. One interesting hypothesis to test is whether countries that remained separate despite potential growth effects of merging, have done so because political integration would have entailed large increases in heterogeneity.

Appendix 1

Derivation of Equation (5)

At each time t, the resource constraint for each input $i \in [0, W]$ produced in a region i belonging to a specific country a of size S_a is:

$$S_a x_{ia}(t) + \sum_{n \neq a} S_n f_{in}(t) = K_i(t). \tag{A.1}$$

Equations (4) and (A.1) imply that each region in country a will use the same amount of domestically produced input i:

$$x_{ia}(t) = \frac{K_i(t)}{S_a + \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}}. \tag{A.2}$$

On the other hand, each region of a country $b \neq a$ will purchase the following amount of input i produced in country a:

$$f_{ib}(t) = \frac{(1 - \xi_a - \xi_b)^{\frac{\alpha}{1-\alpha}} K_i(t)}{S_a + \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}} \tag{A.3}$$

By substituting (A.2) into (4) we obtain equation (5).

Derivation of Equation (8)

Equation (8) is obtained from equation (3) by substituting domestically produced and imported intermediate inputs with their equilibrium values, as specified in equations (A.2) and (A.3), and the levels of capital with their steady-state values, using the fact that all regions belonging to the same country n have the same steady-state level of capital K_n^{ss}, given by equation (7), that is:

$$K_n^{ss} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \left[S_n + \sum_{n \neq m} S_m (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}} \right]. \tag{A.4}$$

Therefore, we have:

$$y_i^{ss} = \int_0^W (x_{ji}^{ss})^\alpha dj = S_a (x_a^{ss})^\alpha + \sum\nolimits_{n \neq a} S_n (1 - \xi_a - \xi_n)^\alpha (f_n^{ss})^\alpha. \tag{A.5}$$

In steady state domestically produced inputs are given by

$$x_a^{ss} = \frac{K_a^{ss}}{S_a + \sum_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \tag{A.6}$$

while imported inputs are given by

$$f_n^{ss} = \frac{(1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}} K_n^{ss}}{S_n + \sum_{m \neq n} S_n (1 - \xi_n - \xi_m)^{\frac{\alpha}{1-\alpha}}} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}. \tag{A.7}$$

Hence we have:

$$\begin{aligned} y_i^{ss} &= S_a \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} + \sum\nolimits_{n \neq a} S_n (1 - \xi_a - \xi_n)^\alpha \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} [(1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}}]^\alpha \\ &= \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left[S_a + \sum\nolimits_{n \neq a} S_n (1 - \xi_a - \xi_n)^{\frac{\alpha}{1-\alpha}} \right]. \end{aligned} \tag{A.8}$$

Appendix 2

The reduced form parameters in equation (36) are:

$$\begin{cases} \gamma_0 = \beta_0 + \beta_2 \alpha_0 \\ \gamma_1 = \beta_1 \\ \gamma_2 = \beta_3 + \beta_2 \alpha_1 + \beta_4 \alpha_0 \\ \gamma_3 = \beta_4 \alpha_1 \\ \gamma_4 = \beta_4 \alpha_2 \\ \gamma_5 = \beta_4 \\ \gamma_6 = \beta_2 \alpha_2 \\ \gamma_7 = \beta_5 \\ \mu_{it} = \varepsilon_i + \beta_2 v_{it} \end{cases}$$

Appendix 3

A. Alternative treatment of the error term

Instead of computing the expected effect of a size merger on growth ignoring the error term (equation 37), we can compute:

$$\begin{aligned}\Delta G^{e}_{abt} &\equiv \Delta \log \frac{y_{at}}{y_{at-\tau}}\\ &= \log\left(\frac{S_{mt}}{S_{at}}\right)\left[\gamma_2 + \gamma_3 \log\left(S_{at}S_{mt}\right) + \gamma_4' W_{at} + \gamma_5 \nu_{at}\right] \qquad \text{(A.9)}\end{aligned}$$

and replace γ_2, γ_3, γ_4 and ν_{at} with their regression estimates in computing the empirical ΔG^{e}_{abt}. In equation (A.9), the superscript "*e*" indicates that the residual terms are taken into account. Note that since the error term of the growth regression, μ_{at}, is assumed to be unchanged between the merged and unmerged states, it gets differenced away from equation (A.9). [50]

Things are more interesting when we turn to "full integration". We can now treat the error terms as additional (unobserved) growth determinants, and compute the empirical ΔG^{me}_{abt} directly using the appropriate population weighted averages of the estimated residuals:

$$\begin{aligned}\Delta G^{me}_{abt} &\equiv \Delta \log \frac{y_{at}}{y_{at-\tau}}\\ &= \log\left(\frac{S_{mt}}{S_{at}}\right)\left[\gamma_2 + \gamma_3 \log\left(S_{at}S_{mt}\right) + \gamma_4' W_{at} + \gamma_5 \nu_{at}\right]\\ &\quad + \gamma_1 \log \frac{y_{mt-\tau}}{y_{at-\tau}} + \left[\gamma_6' + \gamma_4' \log S_{mt}\right]\left[W_{mt} - W_{at}\right]\\ &\quad + \gamma_7'\left[Z_{mt} - Z_{at}\right] + \left(\nu_{mt} - \nu_{at}\right)\left[\gamma_5 \log S_{mt}\right] + \mu_{mt} - \mu_{at}, \qquad \text{(A.10)}\end{aligned}$$

where ν_{mt} and μ_{mt} are the population weighted averages of ν_{at} and ν_{bt} and μ_{at} and μ_{bt}. Again, this equation involves the same terms as equation (A.9), with the steady-state determination effect (including that which results from merging the estimated unexplained portion of growth) added on.

B. The effect of mergers on steady-state income levels

Theory delivers a growth equation of the following form, based on equation (9):

$$\log \frac{y_{at}}{y_{at-\tau}} = \lambda\left(\log y_a^{ss} - \log y_{at-\tau}\right) + \varepsilon_{at}, \qquad \text{(A.11)}$$

50 The only reason ν_{at} remains in this equation is the nonlinearity of the effect of country size on growth brought forth by the interaction term between openness and size in the growth equation.

where y_{at} is current income per capita, $y_{at-\tau}$ is initial income per capita, and y_a^{ss} is (unobserved) income in steady-state.[51] Assume that the steady-state level of income takes the form:

$$\log y_a^{ss} = \delta_1 + \delta_2 O_{at} + \delta_3 \log S_{at} + \delta_4 O_{at} \log S_{at} + \delta_5' Z_{at}. \tag{A.12}$$

This specification choice for $\log y_a^{ss}$ reflects the fact that the right-hand side variables of empirical growth regressions (except initial income) are to be interpreted as the determinants of the steady-state level of income in the neoclassical growth model. On the other hand, our actual growth specification is that of equation (34):

$$\begin{aligned}\log \frac{y_{at}}{y_{at-\tau}} &= \beta_0 + \beta_1 \log y_{at-\tau} + \beta_2 O_{at} + \beta_3 \log S_{at} \\ &\quad + \beta_4 O_{at} \log S_{at} + \beta_5' Z_{at} + \varepsilon_{at}.\end{aligned} \tag{A.13}$$

Substituting equation (A.12) into equation (A.11), we can write:

$$\begin{aligned}\log \frac{y_{at}}{y_{at-\tau}} &= \lambda\delta_1 + \lambda\delta_2 O_{at} + \lambda\delta_3 \log S_{at} \\ &\quad + \lambda\delta_4 O_{at} \log S_{at} + \lambda\delta_5' Z_{at} - \lambda \log y_{at-\tau} + \varepsilon_{at}.\end{aligned} \tag{A.14}$$

Thus, we can recover:[52]

$$\log y_a^{ss} = -\frac{\beta_0}{\beta_1} - \frac{\beta_2}{\beta_1} O_{at} - \frac{\beta_3}{\beta_1} \log S_{at} - \frac{\beta_4}{\beta_1} O_{at} \log S_{at} - \frac{1}{\beta_1} \beta_5' Z_{at}. \tag{A.15}$$

This provides a methodology for backing out the effects of political mergers on steady-state income levels. The percentage change in the steady-state income level of country a after merging with country b can be computed in terms of the reduced form parameters defined in Appendix 2, under the two scenarios under consideration—a pure size merger or full political integration:

$$\begin{aligned}\Delta YSS_{abt} &\equiv E\left(\Delta \log y_a^{ss} | S_{at}, S_{mt}, W_{at}\right) \\ &= -\frac{1}{\gamma_1} \log \frac{S_{mt}}{S_{at}} \left[\gamma_2 + \gamma_3 \log (S_{at} S_{mt}) + \gamma_4' W_{at}\right]\end{aligned} \tag{A.16}$$

and:

$$\begin{aligned}\Delta YSS^m_{abt} &\equiv E\left(\Delta \log y_a^{ss} | S_{at}, S_{mt}, W_{at}, W_{mt}, Z_{at}, Z_{mt}\right) \\ &= -\frac{1}{\gamma_1} [\log \frac{S_{mt}}{S_{at}} \left(\gamma_2 + \gamma_3 \log (S_{at} S_{mt}) + \gamma_4' W_{at}\right) \\ &\quad + \left(\gamma_4' \log S_{mt} + \gamma_6'\right) (W_{mt} - W_{at}) + \gamma_7' (Z_{mt} - Z_{at})].\end{aligned} \tag{A.17}$$

Equations (A.16) and (A.17) are the analogs to equations (37) and (39), respectively, applied to income levels rather than growth. Note that equation (A.16)

51 See Barro and Sala-i-Martin (1995), p. 37 and p. 82 for a derivation of this standard specification in the context of the neoclassical growth model.

52 Note that β_1, the conditional convergence coefficient, is negative.

implies that ΔYSS_{abt} is simply $-1/\gamma_1$ times ΔG_{abt}—hence, since $\gamma_1 = \beta_1$ is negative, the effect of a size merger on steady-state income will have the same sign as its effect on economic growth. However, the signs of ΔYSS^m_{abt} and ΔG^m_{abt} may differ. This is because we have:

$$\Delta G^m_{abt} = \gamma_1 \left(\log \frac{y_{mt-\tau}}{y_{at-\tau}} - \Delta YSS^m_{abt} \right) \tag{A.18}$$

A country a that has a positive steady-state level effect ΔYSS^m_{abt} of full integration may display a negative growth effect ΔG^m_{abt} simply because it has a sufficiently low initial level of income relative to country b (and hence enjoys relatively fast growth holding the steady-state level of income constant). This is because initial income is one of the growth determinants used to calculate the effect of borders on growth under "full integration": an initially poor country on its own would grow fast due to the forces of convergence (holding steady-state determinants constant) but under the merged state might find itself with a higher initial income level (since the initial incomes of merging countries get averaged under this scenario), resulting in lower transitional growth.

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