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Demand-led Industrialisation Policy in a Dual-Sector Small Open Economy

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Abstract

This article models the process of structural transformation and catching-up in a demand-led Southern economy constrained by its balance of payments. Starting from the Sraffian Supermultiplier Model, we model a dual-sector small open economy with a traditional and a modern sector, and that interacts with a technologically advanced Northern economy. We propose two (alternative) autonomous elements that define the growth rate of this demand-led economy: government spending and exports. Drawing from the Structuralist literature, productivity in the technologically laggard Southern economy grows by absorbing technology from the Northern economy, by both embodied and disembodied spillovers, and potentially closing the technology gap. The gap affects the income elasticity of exports, bringing a supply-side mediation to the growth rates in line with the Balance of Payments Constrained Model. We observe that a demand-led government policy plays a central role in structural change, pushing the modern sector to a larger share of employment than what results under export-led growth. Such demand policy is the only way in which partial catching up (in productivity and GDP per capita) can result, and this is facilitated by a global market place in which the balance of payments constraint is relatively soft.

Keywords: Industrialisation; Catching-up; Balance of Payments constrained growth; Sraffian Supermultiplier; Demand-led growth; Dual economy.

JEL: O41, E12, E61

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1. Introduction

The process of structural transformation involves moving from a dominance of traditional sectors to modern sectors of production. Here, "traditional sectors" refers to economic activities with low (or no) productivity growth that can be undertaken without much capital investment or formal education. Subsistence farming is a typical example, but also certain service activities in an urban context, such as street vending, fall under this heading. The "modern sector" consists of manufacturing, where productivity growth can be high and investment in physical and human capital is necessary, along with some of the more dynamic services sectors such as telecommunications (Lavopa and Szirmai, 2018). Thus, since the (first) Industrial Revolution, structural transformation has been connected directly with productivity increases, urbanisation, and moving from primary to manufacturing activities (Deane, 1979). These ideas can be traced back to Lewis (1954) and structuralist thinkers such as Prebisch (1950), and are now prominent in thinking about development.

The industrial revolution emancipated some societies from the Malthusian trap (Kögel & Prskawetz, 2001), generating productivity growth, increases in wages, and improvements in science and in life conditions (increased life expectancy, educational levels) (Hartwell, 2017). But this process has been quite uneven around the globe (Fagerberg, 1994) and, while some countries have managed to achieve a strong process of structural transformation, many other economies in developing regions still struggle to start and advance their own process of catching up (Fagerberg & Godinho, 2004). Thus, how economies can manage to leave a pre-industrial fully traditional economy behind, and move towards the constitution of modern high-productive sectors, has become a crucial question, with deep policy impact.

Some features of the process of structural transformation have shown a degree of commonality. Laggard economies that successfully catch up (as the case of South Korea) are the ones that have managed to absorb and adapt foreign technology (Cimoli & Porcile, 2014; Cimoli et al., 2019; Fagerberg, 1994). The recent experiences of catching up in developing economies are usually connected to a strong government presence, as we see in China. Countries that have developed a strong modern sector have managed to relax their external constraints by diversifying the productive structure, and increasing their growth rates to be compatible with balance-of-payments constraints (Thirlwall, 1979; Sasaki, 2021).

In terms of policy, a prominent idea is that of the so-called developmental state (Wade, 2018), which, broadly speaking, refers to a government that takes an active and leading role in organising structural transformation. The cases of South East Asian nations such as Japan, South Korea, and Taiwan, which realised quick structural transformation and the associated rapid economic growth, are seen as key examples of this type of policy. In the idea of the developmental state, the emphasis lies mostly on supply-side policies, for example aimed at promoting technological learning, often through the adoption of foreign knowledge, the selection of specific sectors as policy targets, and stimulating exports.

In this paper, we want to analyse the potential influence of a demand-led policy for structural transformation, or industrialisation. The idea is that the development of a modern sector may not only be stimulated by foreign demand (exports), but also by domestic demand. Domestic demand may work through the wages of workers in the modern sector (i.e., a multiplier process), but government demand for modern-sector products may reinforce this effect. Our research question is therefore whether a demand-led policy for structural transformation (or industrialisation) may work and, if so, under which circumstances, and how will it influence the growth rate of the economy. Although our approach will not address the issue of supply-side policy, we do not want to suggest that supply-side policy is unimportant. We only want to bring forward the (theoretical) implications of a demand-led policy, while not underrating the importance of supply-side policy for industrialisation. Indeed, some of the parameters in our model that are shown to determine the extent to which demand-side policies can be effective for catching up, are likely to be affected by supply-side policies.

Our model of structural transformation is based on a range of interconnected theoretical approaches. The backbone of the model derives from the Sraffian Supermultiplier Model (SSM; Freitas & Serrano, 2015), which offers a demand-led long-run growth framework that has recently gained momentum. The SSM is a macroeconomic model with a fully endogenous investment function (accelerator mechanism) that (a) increases the traditional Keynesian multiplier, generating higher multiplicative effects of autonomous spending, and (b) proposes that firms plan their production capacity with reference to a long-run capacity-utilisation rate.

We expand the SSM model by splitting the economy into a dual-sector structure composed of a low-productivity traditional sector and a modern, advanced sector. This part of our model is inspired by structuralist thinking, in particular Porcile (2021) and Lavopa (2015). From an initial situation in which the economy consists largely of the traditional sector, we observe, under certain conditions (that we discuss in this paper), transition dynamics towards structural modernisation. Government intervention in the form of a demand policy brings the economy on a path towards a larger modern sector. This government role goes in the same direction as Deleidi and Mazzucato (2019) and Freitas and Christianes (2020). Without government autonomous spending, the economy stays trapped in a low share of the modern sector.

In reaching this result, we expand the original SSM model into one of a Southern small open economy that interacts with the rest of the world through (1) international trade (imports and exports) and (2) absorption of technological knowledge, as the Southern economy is a technologically laggard as in the structuralist framework (Cimoli & Porcile, 2014). The presence of a technological gap, however, creates important catching-up opportunities (Verspagen, 1992; Lee & Malerba, 2017). Also, this Southern economy faces a balance of payments restriction in the sense of a limit on accumulated foreign debt as a result of trade, which allows us to include elements from the Balance of Payments Constrained model (BPCM) (Thirlwall, 1979).

The paper is organized in the following way: after this introduction, Section 2 presents a brief review of relevant literature. In Section 3, we introduce our model. In Section 4 we present the steady state results (there are four possible steady state regimes, of which one appears unstable). Section 5 discusses the results in light of the debates, as well as the specificities of the model. Finally, we conclude the paper in Section 6. An appendix provides the formal derivation of the steady states.

2. Literature Review

2.1. Dual sector economy

The process of economic development in industrial economies involves a strong sectoral reallocation towards dynamic activities. Lewis (1954) modelled this process of structural transformation in his dual-sector dynamic model, focusing on the transition from an economy dominated by a traditional, low-productivity agricultural sector to one containing a modern, industrial urban sector. In the Lewis model, an endogenous dynamic of capital accumulation gives rise to the modern sector that absorbs employment from the traditional sector, thereby increasing the average productivity of the economy.

Prebisch (1949) and ECLAC (1955), pioneers in the Latin American Structuralist (LAS) literature, position a similar kind of dynamic argument into a context of a global Center-Periphery system where the diversified North (Center) takes the lead in innovation (technical change) while the specialized South (periphery) lags behind (see Rodriguez, 2007). In the LAS framework, the productive structure of the Center/North constantly diversifies (Lavopa, 2015) while the Southern economy benefits only in a partial way from the technological change done in the North (Botta, 2009). The adoption of cutting-edge technologies in the South is fragmented, localized, and concentrated in export activities (Porcile, 2021), centered only in a few modern industries that absorb a small part of the workforce (Prebisch 1976; Pinto 1976; Sunkel 1978). The South further concentrates its economic activities in less technology-intensive sectors, such as commodity production, while its labor market remains highly segregated, with a high share of workers in activities with very low productivity (subsistence sector). In summary, the North is diversified and shows homogeneous labor productivity across sectors while the South only specializes in a narrow set of commodities with large differences in labor productivity, within and between sectors (Cimoli & Porcile, 2014).

The central role of manufacturing as a driver of economic growth has recently been reinforced by authors such as Szirmai (2012) and Rodrik (2016). While some economies in Africa and Asia, such as Somalia, Ethiopia and Kenia, are trapped in low development with a very large traditional primary sector (Felipe et al., 2012), some other economies, especially in Latin America, have observed a partial movement towards the adoption of modern activities. Thus, the Center-Periphery dynamics of the LAS may also be interpreted as a middle-income trap (Felipe et al., 2012; Andreoni & Tregenna, 2020), the severity of which seems to be stressed by the fact that some of these economies now suffer from premature deindustrialisation (Rodrick, 2016; Tregenna, 2016).

The transition to a modern economy, out of a middle- or low-income trap, is far from automatic and it may not occur at all. The lack of conditions to allow for a widespread process of structural transformation creates barriers to the transition, while the economies stay trapped in traditional, low-tech activities. The way to overcome these barriers will then depend on the institutional and structural conditions of the economy regarding the external sector, and the role of government as a development agent in the process.

Also, as observed in the structuralist theory, urbanisation in developing economies has resulted in the emergence of a large informal sector, mostly situated in the service sector (Lavopa, 2015). A high informality and the predominance of traditional activities in cities strengthen inequality, being the source of the widespread emergence of slums and other marginalised urban structures (Marx et al., 2013). Thus, Lavopa (2015) and Lavopa and Szirmai (2018) propose an update to the concepts of modern and traditional in the dual-sector framework of the Lewis model. The authors split the service sector by the degree of productivity of each sub-sector, labelling those as modern or traditional sectors. Using this new dichotomy, we are able to capture in a unified framework the problem of structural transformation, detaching it from a classical view mostly related to urbanisation.

2.2. The External Sector and the Balance of Payments Constraint

The external sector and the balance of payments play a large role in the Center-Periphery dynamics of the LAS. Prebisch (1950) focuses on the role of international price dynamics, in particular a tendency of decline in the terms of trade for the South, as traditional goods tend to become cheaper faster than modern goods. On the other hand, the Balance-of-Payments Constrained Model (BPCM) of economic growth, developed by Thirlwall (1979) and McCombie and Thirlwall (2004), abstracts from price dynamics by assuming that in the long run the real exchange rate does not matter (for an extensive review of this literature, see Blecker & Setterfield, 2019).

In the BPCM, growth is constrained in the long run by the need for stability in the external sector. In the approach known as Thirlwall's law (Thirlwall, 1979; McCombie, 2012), the constraint expresses itself through the ratio between the income elasticities of demand for exports and imports. The literature on the BPCM has been a central contribution of the Keynesian tradition, with relevant empirical evidence, as can be observed in the reviews by Blecker and Setterfield (2019) and Blecker (2021).

While the original Thirlwall's law (Thirlwall, 1979) imposes a strict dynamic balance of payments equilibrium, subsequent literature has relaxed this harsh restriction. Thirlwall and Hussain (1982) allow trade deficits by also incorporating capital inflows, which then become part of the constraint. McCombie and Thirlwall (1997), Moreno Brid (1998), and Barbosa-Filho (2001), among others, extended this to an approach where the BOP restriction is stated in terms of a stable ratio of (accumulated) trade deficits to GDP. Such a constraint is 'softer' than the original Thirlwall's law, with a role for international financial markets in determining the harshness (or softness) of the constraint.

The external sector, and in particular imports, has also played a large role in the structuralist debate on the supply side of the economy. In Hirschman's (1968) recommendation of *import substitution*, the international division of labor is changed in favour of the periphery when these countries diversify by producing domestically the high-tech goods that they used to import (de Paula & Jabbour, 2020). That argument, despite being very much criticized later by pro-liberalization economists (Bruton, 1998) and by evolutionary scholars (Fajnzylber, 1990), was partially responsible for policies that resulted in a wave of industrialization in the developing world, as an important part of the modern sector started taking off. Critics of this approach highlight that this take-off was only partial, and has never properly resulted in complete catching-up (leapfrogging), but ended up leading to a middle-income trap (Lin, 2017).

The import-substitution process relies to an important extent on the idea that imports incorporate foreign technology (e.g., Prebisch, 1950, 1959; Singer, 1958; Myrdal, 1956; Seers, 1962), and hence that the successful substitution of these imports will bring technological mastery. Thus, the imports of capital goods, as long as they have not been substituted by domestic technological capabilities, can also be growth-enhancing (Ziesemer, 1995; Hallonsten & Ziesemer, 2016; Lee, 2019), leading to an additional factor in the balance of payments that should be addressed (Ziesemer & Hallonsten, 2019). The mainstream literature on endogenous growth also links the imports of capital goods to long-run growth (Lee, 1995; Carrasco & Tovar-García, 2021; Grossman and Helpman, 1991; Rivera-Bath and Romer; 1991).

2.3. Technology Gap Growth Models, neo-Structuralism and Industrial Policy

Besides imports, there are also other channels of technology diffusion from the center to the periphery. This has been the topic of the literature on long-run growth and technology gaps (e.g., Abramovitz, 1986; Fagerberg, 1994; Fagerberg and Godinho, 2004; Verspagen, 1992). In this approach, technology flows can lead to the development of peripheral countries, but only if technological congruence and domestic capabilities in the developing country is high enough (Abramovitz, 1986). If this is the case, then the technology gap between the center and the periphery will gradually be closed by a process of technology adoption (and adaptation) leading to structural change as envisaged in the structuralist literature that we briefly discussed above.

Porcile (2021) observes a convergence between this literature and the LAS, leading to a neo-structuralist approach. In the theoretical approach that he proposes, Thirlwall's law, as a representation of the equilibrium long-run growth rate in developing economies, is combined with imperfect knowledge flows from the center to the periphery as a result of the technology gap that exists between the two. In this way, we see the idea emerging that a core reason behind international inequality is the interconnected existence of a Center-Periphery division of labour and a Center-Periphery technology gap.

In an early approach in this vein, Cimoli & Porcile (2014) link to the evolutionary discussion on the economics of innovation though the endogenisation of the income elasticity ratio (see also Lavopa, 2015; Porcile & Spinola, 2018). In this way, the income elasticities of demand for exports and imports are seen as related to the degree of diversification of the economy, and the degree of technological capabilities. Countries that have a higher income elasticity of demand for exports are the ones that export more advanced manufactured products, with more embedded knowledge and a higher degree of complexity. The empirical literature indeed highlights a positive correlation between products with higher technology intensiveness and higher income elasticity of demand (Dosi et al., 1990; Gouvea and Lima, 2010; Cimoli & Porcile, 2014; Porcile & Yajima, 2021). The higher the number of products a country can produce, the higher the income elasticity ratio.

Industrial policy is often seen as the main way of stimulating technology adoption and industrialisation, or, in short, modernisation of a developing economy (e.g., Nelson & Pack, 1999; Cimoli et al., 2009). One way in which this can be done is via the so-called developmental state (e.g., Wade, 2018). The idea of the developmental state relies on the idea that markets are not vectors of structural change, but rather of economic specialisation (Chang, 1994). In order to advance with a process of structural change (industrialisation and an increase in modern activities), developing economies need to rely on strong government coordination, goal setting and mobilisation of private actors through government policy. Despite some failures, the main countries that have managed to catch up relied on developmental policies (Altenburg, 2011), as in the case of South Korea, Taiwan and Singapore (Wade, 2018).

The debate on industrial policy has been controversial, with a recent resurge (Aiginger & Rodrik, 2020), but it enters as a fundamental institutional element to lead to the process of catching up and structural change in developing economies (Andreoni & Chang, 2019;

Landesmann & Stöllinger, 2019; Ocampo & Porcile, 2021). The need to create an institutional framework and direct resources to the construction of modern sectors has been shown in the literature as being fundamental in the transition from a low- and low middle-income country to a middle- or high-income country, and the state, in its developmental face (Caldentey, 2008), has played a central historical role in this process.

2.4. Demand and the Sraffian Supermultiplier Model (SSM)

While industrial policy and the developmental state link primarily to the supply side of the economy, the Keynesian tradition (Blecker & Setterfield, 2019) stresses the role of demand, including government demand. This approach starts from a conception of the economic system as possibly suffering from a negative spiral of demand, caused by expectations in a monetary context, in which Say's law is not valid (Davidson, 1972). Such a system needs an injection of demand that can reverse its path in the direction of full employment. The Keynesian view is centred on the short-run mechanisms that may lead the economy to a crisis, and then governmental spending acts as a way to recompose demand and expectations.

One particular incarnation of the Keynesian argument that has attracted much recent attention is the so-called Sraffian Supermultiplier Model (SSM). The SSM approach consists of a demand-led growth model as initially proposed by Freitas and Serrano (2015). In this model, investment is fully endogenised, and the role of demand in growth is reduced to a single parameter, the growth rate of autonomous (i.e., not dependent on current income) consumption demand. Firms aim at maintaining a certain degree of idle capacity, allowing them to react to changes in demand conditions. In the long run, capacity utilisation converges to an exogenous rate. The model stabilises the relationship between productive capacity and aggregate demand by adjustments of the marginal propensity to invest. Because this propensity is an endogenous variable, it enters the multiplier that determines the short-run level of output, resulting in the term supermultiplier.

In the SSM, investment follows a pure accelerator mechanism (capital accumulation induced by income), with no autonomous component. Consumption (either private or public) has an autonomous component that grows at an exogenous growth rate. The short-run level of output adjusts to make savings equal to investment ex-post. Growth is demand-led not only in the short but also in the long run. Finally, economic growth is equal to the exogenous growth rate of autonomous consumption demand, and capital accumulation (given the equilibrium utilisation rate) converges to this rate.

The SSM tradition currently offers a number of alternative sources for the exogenous rate of autonomous demand that determines the growth rate of the economy, and that include workers' autonomous consumption financed out of credit (Freitas & Serrano, 2015) as part of the wealth of the workers (Brochier & Silva, 2019), capitalists' consumption

(Lavoie, 2016), subsistence consumption, including an unemployment benefits system (Allain, 2019), government expenditures (Allain, 2015), exports (Nah & Lavoie, 2017), and R&D investments (Caminati & Sordi, 2019).

The role of government spending in growth has been well-developed by Keynesian authors (e.g., Kaldor, 1957; Blecker & Setterfield, 2019). But government spending may also have a supply-side effect, as in Deleidi and Mazzucato's (2019, 2021) SSM where autonomous government spending takes the form of mission-oriented science and technology policy (Mazzucatto, 2018), which creates, coordinates, and funds research and investment projects that lead to long-run productivity increases (Mazzucatto, 2011).

In this way, a supply-side policy such as a science and technology policy, or industrial policy may also enhance growth and development through the demand side. This leads directly to our interest in whether a Keynesian demand policy can also be used to stimulate development and structural change in the sense of Porcile's neo-structuralist perspective. In the next section, we will construct a dual economy structuralist technology model with an SSM backbone to explore this interest.

3. Model

We consider a dually-structured Southern economy, with a modern and a traditional sector, which interacts with the rest of the world through imports and exports, in line with Nah and Lavoie (2017). Although both the modern and the traditional sectors exist in the country, the traditional sector dominates the economy, and the question we pose is how a demand-led government policy can increase the share of the modern sector in the economy. We specify, analyse and simulate the model in discrete time.

In the traditional sector, workers consume what they produce, i.e., although the sector is counted in GDP, there are no savings, no investment, no imports, and no exports. In this setting, as in the original Lewis approach, we only need to consider the role of the traditional sector as an absorber of workers who cannot find employment in the modern sector. Thus, we start the model exposition by writing the standard macroeconomic income identity, which holds for the modern sector irrespective of the size of the traditional sector:

$$Y_t = C_t + I_t + Z_{Gt} + X_t - M_t \quad (1)$$

where Y is output of the modern sector, C is total consumption of modern sector output, I is total investment in the modern sector (and consisting of modern sector output), Z_G is autonomous government spending on modern sector output, X is total exports of modern output and M total imports of modern sector products of the North. The subscript t indicates time. The corresponding income identity for the traditional sector would be

$Y_t^T = C_t^T$, where the superscript T indicates the traditional sector, but this identity plays no further role in the analysis.

3.1. Short-run output and the supermultiplier

We start the analysis by looking at how the supermultiplier determines output in the short run. Private consumption is fully endogenous, depending only on disposable income:

$$C_t = c(1 - t_t)Y_t \tag{2}$$

where c is the marginal propensity to consume, and t is the tax rate. Following the supermultiplier literature (Freitas & Serrano, 2015), investment is also fully endogenous, following an accelerator mechanism by which the marginal propensity to invest responds to changes in capacity utilization:

$$I_t = h_t Y_t \tag{3}$$

in which h_t is the (endogenous) marginal propensity to invest.

Next, imports M are fully endogenous and a function of current-period modern sector output:

$$M_t = m_t Y_t \tag{4}$$

Note that the propensity to import, m, is time varying (we will provide an equation to endogenize it below). Exports ($\bar{X}_t$) are autonomous, i.e., independent of current period output. Government spending (Z_G) is another component of autonomous spending, representing an important component of long-run growth in the SSM framework. It is defined as proportional to the capital stock, following an approach similar to Nomaler et al. (2021):

$$Z_{Gt} = \zeta_t K_t \tag{5}$$

in which ζ is the marginal propensity of government spending out of economy-wide wealth given by the capital stock.

The income identity (Equation 1) now becomes

$$Y_t = c(1 - t_t)Y_t + h_t Y_t + Z_{Gt} + \bar{X}_t - m_t Y_t \tag{6}$$

This can be used in the conventional way to derive modern sector output as the product of autonomous spending and the supermultiplier:

$$Y_t = (Z_{Gt} + \bar{X}_t)\Omega_t \tag{7}$$

in which the multiplier is given by $\Omega_t \equiv \frac{1}{1-c(1-t_t)-h_t+m_t}$.

3.2. Capital and the labour market

We now have to define the way in which the key variables of the model change in the longer run. We use forward differencing throughout the analysis, i.e., $\Delta V_t = V_{t+1} - V_t$ for any variable V. We start by specifying an equation for the change of h, where we are fully in line with the supermultiplier literature:

$$\Delta h_t = h_{t+1} - h_t = \gamma(u_t - \mu) \tag{8}$$

where μ is the desired long-run capacity utilization ratio, and u is the capital utilization rate, which is defined as $u = \frac{Y}{Y_K}$, where $Y_K = \frac{K}{v}$ is full-capacity output and v is the incremental capital-output ratio. With all this, we have

$$u = v\frac{Y}{K} \tag{9}$$

Capital accumulates in terms of new investments minus depreciation:

$$\Delta K_t = I_t - \delta K_t = h_t Y_t - \delta K_t \tag{10}$$

where δ is the depreciation rate (and we still use the forward difference). Equations (3), (8) and (10) act as a mechanism to take capacity utilization to the long-run level of capacity utilization μ.

Considering a Leontief production function, labour demand in the modern sector is $\frac{Y}{a_M}$, where a_M is labour productivity. Thus, the share of the labour force employed in the modern sector is given by:

$$E_{Mt} = \frac{Y_t}{a_{Mt}N} \tag{11}$$

where N is the total labour force. We assume that there is no population growth, i.e., that the size of the labour force is constant. This assumption does not influence the conclusions in any major way, and we have a full set of derivations that assumes a fixed non-zero rate of growth of the labour force.

Note that the $(1 - E_M)N$ workers not employed in the modern sector are employed in the traditional sector where they earn a subsistence wage that is equal to their productivity, i.e., there are no profits in the traditional sector. We denote the productivity level in the traditional sector by a_T, with $\Delta a_T = 0$.

3.3. Dynamics of the autonomous demand components

We observe that, in Equation (7), there are two autonomous demand components: government spending and exports. We now turn to the specification of these variables, where we draw on the LAS approach and Thirlwall's law. Autonomous exports $\bar{X}$ depend on the growth of the foreign economy and the income elasticity of exports (we consider only quantity effects, so that the price dynamics and the real exchange rate are disregarded, as in the basic Thirlwall approach):

$$\Delta\bar{X}_t = \bar{X}_t \varepsilon_{Xt} g_F \tag{12}$$

where g_F is the exogenous growth rate of foreign income and ε_X is the foreign income elasticity of imports. We model this income elasticity as a function of the technology gap, denoted by G, between the Southern economy and the North:

$$\varepsilon_{Xt} = \varepsilon_0(1 - \varepsilon_1 G_t) \tag{13}$$

This formulation is derived from Lavopa (2015, p. 43), who argues that countries that are closer to the technological frontier (i.e., smaller G) tend to produce higher-quality goods, and that high-quality goods tend to have higher elasticities of demand.

The dynamics of Z_G play a crucial role in the model. In line with, e.g., Alain (2015), we focus on public expenditure as the source of this part of autonomous demand. As we are interested in analysing the role of a demand-led government policy to stimulate the development of the modern sector, we specify autonomous public expenditure to have the aim to bring the employment share of the modern sector to a target level that is denoted by $\bar{E}$. The government adjusts its spending on modern sector output, depending on how far away the economy is from this target, increasing (decreasing) expenditure as long as E_M is below (above) the policy target (this is similar to the approach in Nomaler et al., 2021). The policy instrument for this mechanism is the variable ζ (see equation 5):

$$\zeta_t = max[0, \zeta_{t-1} + \iota(\bar{E} - E_{Mt-1})] \tag{14}$$

where ι is a parameter that specifies the sensitivity of policy. The max(.) operator is necessary in order to avoid negative government spending that would otherwise arise if the employment share of the modern sector is above its target level.

We already specified a tax rate (the traditional sector is not taxed), thus government debt, denoted by Γ, accumulates as

$$\Delta\Gamma_t = (Z_{Gt} - t_t Y_t) \tag{15}$$

We assume that the government doesn't want debt to increase too much, and uses total wealth (defined as the capital stock K) as a yardstick. Thus with $D_t \equiv \Gamma_t/K_t$, government adjusts the tax rate as[1]

$$\Delta t_t = \eta t_t D_t \tag{16}$$

Note that with the definition of D and equation (15), we have

$$\Delta D_t = \left(\frac{1}{\hat{K}_t+1}\right)\left(\zeta_t - \frac{t_t Y_t}{K_t} - D_t \hat{K}_t\right) \tag{17}$$

3.4. The external sector

The Southern economy has a trade deficit S equal to

$$S_t = m_t Y_t - \bar{X}_t \tag{18}$$

As stressed in part of the BOPC literature that we briefly summarized above, the trade deficit accumulates into foreign debt, which we denote by F, so that the following holds:

$$F_t = \sum_{i=1}^{t} S_i \tag{19}$$

$$\Delta F_{t-1} = F_t - F_{t-1} = S_t = m_t Y_t - \bar{X}_t \tag{20}$$

By substituting Y (Equation 7) this turns into

$$\Delta F_{t-1} = m_t \Omega_t \zeta_t K_t - X_t(1 - m_t \Omega_t) \tag{21}$$

For convenience, we will express exports and foreign debt as a fraction of the capital stock, as in $\chi_t \equiv \frac{\bar{X}_t}{K_t}$ that expresses exports as a fraction of the capital stock, and $B_t \equiv \frac{F_{t-1}}{K_t}$ that expresses foreign debt as a fraction of the capital stock.

Applying the forward difference formula to find the change of B we find

$$\Delta B_t = \frac{1}{1+\hat{K}_t}\left(\frac{\Delta F_{t-1}}{K_t} - \hat{K}_t \frac{F_{t-1}}{K_t}\right) = \frac{1}{1+\hat{K}_t}\left(\frac{\Delta F_{t-1}}{K_t} - \hat{K}_t B_t\right) \tag{22}$$

Substituting (21) into (22) yields

$$\Delta B_t = \frac{\zeta m_t \Omega_t - \chi_t(1 - m_t \Omega_t) - B_t \hat{K}_t}{1+\hat{K}_t} \tag{23}$$

After we replace the term Ω_t with the explicit multiplier this turns into

[1] Expressing D, as well as a number of other variables below, as a fraction of K, is, in the steady state, equivalent to expressing those variables as a fraction of Y, because in the steady state Y/K is constant. We prefer using K instead of Y for mathematical convenience.

$$\Delta B_t = \frac{1}{1+\hat{K}_t}\left(\frac{\zeta_t m_t - \chi_t(1-c(1-t_t)-h_t)}{1-c(1-t_t)-h_t+m_t} - B_t\hat{K}_t\right) \tag{24}$$

With the newly defined variables in terms of the stock of capital, equation (7) can be re-written as

$$Y_t = \frac{K_t(\chi_t+\zeta_t)}{1-c(1-t_t)-h_t+m_t} \tag{25}$$

Also, using equations (12) and (13), we have

$$\Delta\chi_t = \frac{\chi_t}{1+\hat{K}_t}\left(\varepsilon_0(1-\varepsilon_1 G_t)g_F - \hat{K}_t\right) \tag{26}$$

Finally, we need an equation that specifies the motion of the propensity to import m. This is where we link to the idea that the BOPC can be seen as a constraint on accumulated trade deficits (see our brief summary of this literature above), and also on the literature that connects imports (of capital goods) to technology flows from the Center/North. We start by defining a parameter $\bar{B}$ that is the maximum value of foreign debt (as a fraction of the capital stock) that South can sustain in the long run. Hence $\bar{B}$ regulates the stringency of the balance of payments constraint that South faces. One specific way in which we may interpret $\bar{B}$ is as North's willingness to take ownership of South's capital stock, or, in other words, to provide foreign direct investment.

In turn, we assume that South is willing to import as much as possible subject to $\bar{B}$. We model this by a dynamic process that consists of the following equations:

$$\Delta m_t = \varphi(\bar{B} - B_t) \tag{27}$$

$$m_t = max(m_{t-1} + \Delta m_t, \bar{m}) \tag{28}$$

Thus, as long as South's foreign debt is below the threshold $\bar{B}$, it will keep increasing its propensity to import m_t, but when foreign debt rises above $\bar{B}$, m_t will fall. This dynamic process is subject to an upper threshold value $\bar{m} < 1$ for the propensity to import.

3.5. Productivity and the knowledge gap

To model labour productivity in the modern sector, we follow Lavopa (2015). This means that we introduce an endogenous Southern knowledge stock, as well as an exogenously growing knowledge stock in the North. Labour productivity in each country is directly related to the knowledge stock, as in $a_{MSt} = \alpha_S T_{St}$ and $a_{MNt} = \alpha_N T_{St}$, where T_S and T_N are the knowledge stocks in the South and the North, respectively, a_{MSt} and a_{MNt} are labour productivity in South and North, and α_S and α_N are parameters.

The two knowledge stocks define the technology gap between the North and the South that we already used in defining the elasticity of South's exports with regard to North's income (Equation 13). The technology gap is defined as

$$G_t = 1 - \frac{T_{St}}{T_{Nt}} \tag{29}$$

For simplicity, we assume zero population growth (also) in North, and that foreign technological knowledge stock (T_N) grows at the same rate as foreign income, i.e., $\widehat{T}_N = g_F$, and also that $\alpha_S = \alpha_N$. The latter assumption means that G_t is not only a technology gap, but also a productivity gap. For notational simplicity, we will write $a_{Mt} = a_{MSt}$ (as we did before in Equation 11).

The knowledge stock in the Southern economy grows at an exogenous rate, by a Kaldor-Verdoorn learning mechanism, (disembodied) knowledge spillovers (catching-up), and embodied knowledge spillovers that are related to imports:

$$\Delta T_{St} = T_{St}\left(\tau_0 + \tau_K \widehat{K}_{St} + \tau_G G_t E_{Mt}(1 + \lambda m_t)\right) \tag{30}$$

where τ_0, τ_K, τ_G and λ are parameters. τ_0 is the exogenous component of productivity growth, and $\tau_K \widehat{K}$ is the Kaldor-Verdoorn learning effect. In line with the technology gap theory, the term $\tau_G G_t E_{Mt}(1 + \lambda m_t)$ captures knowledge spillovers from North. These spillovers depend first of all on the size of the gap G_t, which in this case represents potential spillovers. E_{Mt} appears in the spillover term to represent the effect of technological congruence (Abramovitz, 1986; Verspagen, 1992), which means that South learns more from North if it has a large modern sector. Finally, $(1 + \lambda m_t)$ represents the embodied spillover channel that relates to the import of intermediate and capital goods from North, and the parameter λ regulates the relative importance of this channel.

Box 1. Dual Sector SSM in difference system

$$\Delta h_t = \gamma(u_t - \mu) \tag{8}$$

$$\Delta K_t = h_t Y_t - \delta K_t \tag{10}$$

$$E_{Mt} = \frac{Y_t}{a_{Mt} N} \tag{11}$$

$$\zeta_t = max\left[0, \zeta_{t-1} + \iota(\bar{E} - E_{M_{t-1}})\right] \tag{14}$$

$$\Delta t_t = \eta t_t D_t \tag{16}$$

$$\Delta D_t = \left(\frac{1}{\widehat{K}_t + 1}\right)\left(\zeta_t - \frac{t_t Y_t}{K_t} - D_t \widehat{K}_t\right) \tag{17}$$

$$\Delta B_t = \frac{1}{1 + \widehat{K}_t}\left(\frac{\zeta_t m_t - \chi_t(1 - c(1 - t_t) - h_t)}{1 - c(1 - t_t) - h_t + m_t} - B_t \widehat{K}_t\right) \tag{24}$$

$$Y_t = \frac{K_t(\chi_t + \zeta_t)}{1 - c(1 - t_t) - h_t + m_t} \tag{25}$$

$$\Delta \chi_t = \frac{\chi_t}{1 + \widehat{K}_t}\left(\varepsilon_0(1 - \varepsilon_1 G_t) g_F - \widehat{K}_t\right) \tag{26}$$

$$\Delta m_t = \varphi(\bar{B} - B_t) \tag{27}$$

$$m_t = max(m_{t-1} + \Delta m_t, \bar{m}) \tag{28}$$

$$G_t = 1 - \frac{T_{St}}{T_{Nt}} \tag{29}$$

$$\Delta T_{St} = T_{St}\left(\tau_0 + \tau_K \widehat{K}_{St} + \tau_G G_t E_{Mt}(1 + \lambda m_t)\right) \tag{30}$$

$$\Delta a_{Mt} = a_{Mt} \frac{\Delta T_{St}}{T_{St}} \tag{31}$$

$$\Delta T_{Nt} = T_{Nt} g_F \tag{32}$$

4. Results

This results in the 15 equations in Box 1 that describe the entire model. In this system, ten variables (u, B, h, χ, ζ, D, E_M, G, m and t) are supposed to converge to a constant level at the steady-state, while the other six (K, N, T_S, T_N, a_M, Y) are ever growing variables, but their growth rate converges to a constant level in the steady-state.

4.1. Steady states

We derive the expressions for the steady states of the model in the appendix. As is shown there, there are four different steady states, in a 2×2 configuration that is displayed in Table 1. We use a * superscript to denote steady state values.

The rows of the table distinguish between the cases where the Southern government does or does not intervene with a demand-led industrialisation policy, i.e., the parameter $\bar{E}$. When the government intervenes, i.e., with a sufficiently high value for $\bar{E}$, growth in South will be demand policy-led, and the Southern economy will find itself in the top row. Without such a policy the economy becomes export-led, and the bottom row applies. The two columns of the table distinguish between the cases in which the steady-state technology gap is smaller than one (i.e., partial catch-up) or where it is equal to one (complete falling behind).

Table 1. Steady-state growth rates of the model

	$G^* < 1$	$G^* = 1$
Policy-led growth ($\bar{E}$ high)	$\widehat{K}^* = \hat{a}_M^* = g_F$	$\widehat{K}^* = \hat{a}_M^* = \dfrac{\tau_0 + \tau_G \bar{E}}{1 - \tau_K - \tau_G \lambda \bar{E} \bar{B} \dfrac{v}{\mu}}$
Export-led growth ($\bar{E}$ low)	$\widehat{K}^* = g_F$ Unstable	$\widehat{K}^* = \hat{a}_M^* = \varepsilon_0(1 - \varepsilon_1) g_F$

A formal stability analysis is difficult because of complications in the steady state expressions, but numerical analysis shows that the steady state in the left-bottom cell of the table is unstable. For parameter values where this steady state exists, we observe convergence to the right-bottom cell, i.e., $G^* = 1$, or to state $G^* = 0$, which we rule out because we model South as a technology-following country. For the other cases, numerical simulation confirms that the steady states are stable. Thus, we ignore the bottom-left cell in further analysis.

The export-led case (bottom-right) can be characterized as a Thirlwall state of the Southern economy. Note that our specification of imports dictates that the elasticity of imports with respect to Southern income is exactly unity. Thus, the growth rate $\widehat{K}^*$ is a function of foreign income growth and the elasticity parameters ε_0 and ε_1. In this Thirlwall state, the only autonomous demand is exports, i.e., it derives from foreign income growth (g_F). The Southern growth rate (of productivity and capital) adjusts to the growth rate that is implied by foreign growth and parameters ε_0 and ε_1 to yield a stable and positive value of the employment share of the modern sector, E_M^*.

In the policy-led cases, the foreign economy poses a supply-side restriction (through knowledge spillovers), instead of a demand-side restriction. The demand side of the Southern economy, i.e., autonomous government demand, is now endogenous on the policy target $\bar{E}$, and the knowledge stock, productivity and capital growth in South adjust to Northern productivity growth to keep the technology and productivity gap stable. In summary, while in the Thirlwall (export-led) state, the supply side (capital and productivity) adjusts endogenously to exogenous (and foreign) demand, in the policy-led state, the demand side adjusts endogenously to exogenous (and foreign) productivity growth.

Even in the Thirlwall (export-led) state, South develops a modern sector, i.e., E_M^* is generally > 0 even in the absence of demand policy. But this does not prevent South from falling behind completely, i.e., to converge to $G^* = 1$. Thus, in our model industrialization may be partial, and is not a guaranteed road to development, if we define development as a state of catching up with the global technological frontier.

A few further details about the steady state are worth noticing. First, we can note that the policy variable $\bar{E}$ only affects the growth rate $\widehat{K}^*$ when $G^* = 1$, and in this case the growth rate is increasing in $\bar{E}$, i.e., a more ambitious policy yields a higher growth rate. Any policy that is less ambitious than the value E_M^* that would result without government intervention, will not have any effect, and will not require any government spending. Growth will just remain export-led with such an unambitious policy. It can be verified that the borderline case where $\bar{E} = E_M^*$ yields an identical growth rate between the export-led case and the policy-led case.[2] We may therefore conclude that a policy that does not take South out of a falling behind situation (i.e., G^* remains 1), will increase the growth rate relative to the export-led state, and hence reduce the tempo in which falling behind takes place. The more ambitious such a policy is, the larger its effect will be.

So far, our discussion has mostly focused on the two cases with $G^* = 1$. But catching up ($G^* < 1$) is possible if the government intervenes (top-left cell of the table). In that case, what can be said about the productivity gap in the modern sector, and what does it imply for the corresponding gap in GDP per capita between North and South? For notational simplicity, and without loss of generality, we assume a labour participation rate of 1 in North and in South. Note that in South, employment can either be in the stagnant traditional sector or in the modern sector, while in North all workers are employed in the modern sector. Then GDP per capita in North is simply equal to Northern labour productivity, while GDP per capita in South is equal to $a_{Mt}E_{Mt} + a_T(1 - E_{Mt})$. The gap in

[2] Equating the policy-led growth rate with $\bar{E} = E_M^*$ and the export-led growth rate leads to the expression $\bar{m} = \frac{v\bar{B}}{\mu}\widehat{K}^*$ which says that the steady state values m^* must be equal between the two cases (see appendix for the steady state values m^* for $G^* = 1$).

GDP per capita between North and South can then be written in similar fashion to the knowledge and productivity gap before:

$$Q_t = 1 - \frac{a_{Mt}E_{Mt} + a_T(1 - E_{Mt})}{a_{MNt}}$$

where Q is the GDP per capita gap between North and South. Note that in the steady state, the term $\frac{a_T}{a_{MNt}}$ will tend to zero because a_T does not grow and a_{MNt} grows exponentially. Therefore, the steady state GDP per capita gap is

$$Q^* = 1 - (1 - G^*)E_M^*$$

where we have $E_M^* = \bar{E}$ if the government choses to intervene. From this expression, it can be seen that as long as $G^* = 1$, $Q^* = 1$, irrespective of any level of industrialization E_M^*. But if the government manages, by means of demand policy, to bring the Southern economy to a state of technological catching up ($G^* < 1$), then the gap in terms of GDP per capita will also be smaller than 1.

Technological catching up is only possible with government demand policy, and as we show in the appendix, if technological catching up takes place, then the technology gap can be expressed as

$$G^* = \frac{g_F(1 - \tau_K) - \tau_0}{\tau_G \bar{E}(1 + \lambda m^*)}$$

Note that due to parameter values and/or due to $\bar{E}$ being too low, the righthand side of this expression may be > 1, which would imply that technological catching up is not possible.

By substituting this as well as the steady state expression $m^* = \frac{v}{\mu}\bar{B}g_F$ into the expression for the steady state GDP per capita gap, we find

$$Q^* = 1 - \bar{E} + \frac{g_F(1 - \tau_K) - \tau_0}{\tau_G\left(1 + g_F\lambda\bar{B}\frac{v}{\mu}\right)}$$

Seen in this way, the demand policy target $\bar{E}$ directly contributes to lowering Q^* by decreasing the share of the traditional sector $(1 - \bar{E})$. But even if $\bar{E} = 1$, i.e., if the traditional sector vanishes completely, a positive GDP per capita gap will remain as a result of the last term on the righthand side.

This term is solely dependent on supply-side parameters (which may be influenced by supply side policy, although we consider that to be outside the scope of our paper). The term is decreasing in τ_G, τ_K, and τ_0, which implies that all these “learning-related” parameters tend to lower the GDP per capita gap with North if South manages to catch up. It is increasing in g_F as long as $\tau_K < 1$, which means that if North grows faster, Q^* will grow.

Finally, the denominator of the last term on the righthand side contains the impact of the embodied import spillovers channel on Q^*, including the parameters λ and $\bar{B}$. An increase in either of these will lower Q^*. As λ measures the importance of import-embodied spillovers, and $\bar{B}$ reflects the stringency of the Southern balance of payments constraint that exists in the global market, the multiplicative term $\lambda\bar{B}$ in the last term of the equation for Q^* reflects that the more important import-embodied spillovers are, the more the stringency of the balance of payments constraint matters for the steady state GDP per capita gap, and vice versa.

5. Discussion

Our model draws on four types of stability mechanisms for the Southern economy: (1) stability in the productive system in terms of capacity utilisation, (2) stability in the labour market in terms of the employment rate in the modern sector, (3) stability of the external sector in terms of the trade balance, and (4) stability in terms of knowledge flows (from North to South) acting on the technology gap.

The stability of capital utilisation is defined by the original SSM (Freitas & Serrano, 2015). Firms have a desired level of capacity utilisation, and they adjust their investment decision (marginal propensity to invest) in order to lead the actual level of capacity utilisation of the economy to its desired level. For stability in terms of employment, we draw on the approach of Nomaler et al. (2021). Government policy implements a spending mechanism that answers to differences of effective employment in the modern sector from the target rate, which is a share of employment in the modern sector. In terms of the external sector, foreign debt results from the trade balance, and imports are adjusted as a result of foreign debt accumulation. The foreign income elasticity of exports is defined by the structural conditions of the economy (Lavopa, 2015; Porcile & Spinola, 2018), given by technology-accumulated knowledge. In terms of the knowledge gap, which is also a productivity gap, adjustment takes place by means of embodied (in imports) and disembodied spillovers.

Not all of these adjustment mechanisms have to be in operation all the time. Depending on which mechanisms work, the model has multiple equilibria (steady states). In this respect, the most important conclusion is that without an active demand policy by the Southern government, South will never catch up to North in terms of technological knowledge, nor in terms of GDP per capita. Without demand policy, the economy is export-led in a way that is reminiscent of Thirlwall's law, meaning that the Southern growth rate is determined by foreign income elasticity of exports and the foreign growth rate. A relatively small modern sector will tend to emerge in this state, but technological catchup is impossible, because the steady state that represents catching-up in the Thirlwall state is unstable.

With sufficiently ambitious government demand policy, the adjustment mechanism of government demand takes over from exports, i.e., the economy becomes demand policy-led instead of export-led. The development of the modern sector is the mechanism by which catching-up takes place. But it is possible that supply side conditions prohibit catching up, i.e., that no policy is ambitious enough, for example because learning capacity in South is too low.

The balance of payments constraint also plays a role in whether or not catching up is possible, and, if it is possible, how much South will converge relative to GDP per capita in North. A softer balance of payments constraint, which is modelled through the extent to which Southern foreign debt is allowed to accumulate from subsequent trade balance deficits, will facilitate imports into South, which are accompanied by embodied technology spillovers. As a result, a softer (harsher) balance of payments constraint will make catching up easier (harder), and lead to stronger (weaker) convergence.

6. Conclusions

In our theoretical model, which is based on a range of different approaches to structural change and development, government consumption demand can be an important component of industrialisation policy. Although the economy that we model can develop a modern sector without notable government consumption, industrialisation can be further enhanced by a demand-led policy, even with a balanced government budget. We derived multiple steady states that illustrate this point.

While it makes this specific point, our model also shows how various interrelated approaches to the topics of structural change and development that are often applied and analysed in isolation, can be usefully applied in a coherent model. Thus, the model has applicability beyond the topic of demand-led policy. For example, while many of the supply-side policies aimed at learning and technology adaption and adaptation re represented by parameters in our model, this side could easily be extended to analyze such policies in an explicit way. In terms of 'pure' theory, our model also shows how the demand-side approach of the supermultiplier can be combined with supply side dynamics to yield different steady state regimes in which either the demand- or the supply side dominates the dynamic path that the economy is on.

However, our approach has been exclusively theoretical. Although we draw on several mechanisms that are well-documented in the literature, such as learning and technology spillovers, we did not attempt any empirical estimation or even calibration of the parameters of the model.

Future empirical work will be necessary to gain insight, for example, into how far government consumption demand can go to stimulate industrialisation. We feel that this is a gap in the literature, which has focused mainly on supply-side policies for industrialisation. Although we do not want to detract from the importance of supply-side policy, we also feel that more attention to the potential role of a demand-led industrialisation policy will be useful. We hope that our model will provide an opportunity to explore this topic, whether it is as a calibrated simulation model, or as a guidance for quantitative or qualitative analysis of (historical) empirical data on the role of government consumption in industrialising economies.

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Appendix. Derivation of the steady states

The core of the model is formed by a subsystem of the two variables G and E_M. Each of these variables has two possible (and meaningful) steady states, yielding, in principle, $2 \times 2 = 4$ steady state configurations for the entire model. However, as we will show, only 3 of those possible configurations exhibit sufficient stability to be analytically useful.

The core subsystem has two equations. The first is obtained by differentiating Equation (29) with respect to time:

$$\Delta G_t = -\frac{T_{St}}{T_{Nt}}\left(\hat{T}_{St} - \hat{T}_{Nt}\right)\frac{1}{1+\hat{T}_{Nt}} = (1 - G_t)\left(\hat{T}_{Nt} - \hat{T}_{St}\right)\frac{1}{1+\hat{T}_{Nt}} \tag{33}$$

The other equation of the core subsystem uses the definition of E_M (Equation 11), the assumption of no population growth (constant N) and the definition $\frac{Y_t}{K_t} = \frac{\mu}{v}$, and says that in order to maintain a constant (non-zero) value of E_M, we need

$$\widehat{K}_t = \hat{a}_{Mt} \tag{34}$$

To see the nature of the steady state in each of the general configurations of this subsystem, consider first Equation (33). For the technology gap to be stable, this equation needs to be equal to zero, and there are two possibilities to achieve this. The first is $G^* = 1$ (we use a * superscript to denote steady state values), which corresponds to complete falling behind of the South in terms of knowledge and productivity.

The second possibility is $\hat{T}_{St} = \hat{T}_{Nt}$, i.e., that the knowledge stocks (and hence productivity) in North and South grow at an equal rate, which is g_F (Equation 32). This implies that the rate of knowledge growth in South (Equation 30) needs to adjust to become equal to g_F. In case $G^* = 1$, such adjustment is not necessary, and knowledge (productivity) in South will grow at a slower rate than g_F.

There are also two possibilities for which stable value of E_M is obtained. Equation (34) leads to one possibility, but this only holds when the government decides not to intervene. If, on the other hand, the government does (successfully) intervene and sets a value $\bar{E}$ that is higher than what would be achieved without government intervention, then Equation (34) does not need to hold. If the government intervenes, then the value $\bar{E}$ is maintained by government demand influencing output (and capital formation $\widehat{K}$) through the supermultiplier. In case Equation (34) holds, a value E_M^* will result from exogenous export demand (working on $\widehat{K}$), and productivity growth, which is strongly related to Equation (33).

It can immediately be seen how the decision on government intervention has consequences beyond the core subsystem. If the government does not intervene (or sets a target $\bar{E}$ below E_M^* that would result without intervention), then Equation (14) shows that the spending variable ζ will converge to zero, i.e., $\zeta^* = 0$. Moreover, equation (16) shows that irrespective of the value of ζ, the government debt variable D must have steady state value zero for the tax rate t to be in steady state. Then, with $\zeta^* = 0$ and $D^* = 0$, Equation (17) also implies $t^* = 0$. In summary, as long as $\bar{E} < E_M^*$, the government does not spend and does not tax, and consequently has no debt.

There is a further consequence from the absence of government intervention ($\bar{E} < E_M^*$), which can be seen when we set equation (24) to zero to find a steady state for B. With $\zeta^* = 0$, and hence $t^* = 0$, this leads to

$$\Delta B_t = -\frac{1}{1+\hat{K}_t}\left(\frac{\chi_t(1-c-h_t)}{1-c-h_t+m_t} + B_t\hat{K}_t\right) = 0 \Rightarrow B^* < 0 \tag{35}$$

With B^* negative, South accumulates an external surplus, not a deficit, and because the parameter $\bar{B} > 0$, Equation (27) then says that in the steady state, m will keep increasing until it reaches the maximum level $\bar{m}$ that Equation (28) imposes. Thus, without government intervention, $m^* = \bar{m}$.

The absence or presence of government intervention also has consequences for the export variable χ. A stable value for this variable results if Equation (26) is zero, which yields two options:

$$\hat{K}_t = \varepsilon_0(1-\varepsilon_1 G_t)g_F \text{ or } \chi^* = 0 \tag{36}$$

As the model contains two sources of autonomous demand, exports and government spending, a steady state where $\chi^* = 0$ depends exclusively on government spending to generate growth, i.e., in this case the Southern economy is demand policy-led. On the other hand, $\hat{K}_t = \varepsilon_0(1-\varepsilon_1 G_t)g_F$ in Equation (36) clearly corresponds to export-led growth, because in this case the capital stock grows at the same rate as exports ($\varepsilon_0(1-\varepsilon_1 G_t)g_F$ is the growth rate of exports, see Equations 12 and 13). Below we will show more explicitly that government intervention ($\bar{E} > E_M^*$) implies $\chi^* = 0$, i.e., that the economy in South is either export-led or demand policy-led, but not both at the same time.

Export-led growth (no government intervention) with $G^* < 1$

We now proceed to derive the complete set of steady state values when there is no government intervention, and South manages to partially catch up in terms of knowledge and productivity ($G^* < 1$). As there is no government intervention, and as explained above, the following must hold to reach a steady state $\chi^* > 0$:

$$\hat{K}_t = \varepsilon_0(1-\varepsilon_1 G_t)g_F \tag{37}$$

Because we look for a steady state where $G^* < 1$, we need $\hat{T}_{St} = \hat{T}_{Nt}$ in Equation (33). As already noted before (and also writing equations 31 and 32 in rate of change terms), this leads to

$$\hat{a}_{Mt} = \hat{T}_{St} = g_F \tag{38}$$

We can substitute Equations (30) and (37) and also use $m^* = \bar{m}$ (because there is no government intervention) to obtain

$$\tau_0 + \tau_K \varepsilon_0 (1 - \varepsilon_1 G_t) g_F + \tau_G G_t E_{Mt} (1 + \lambda \bar{m}) = g_F \tag{39}$$

This equation only contains the variables G and E_M, which we identified as the two variables in the core subsystem of the model.

Equation (34) is the requirement for a steady state of E_M, and under the conditions that we are currently considering, we can substitute the lefthand side of Equation (39) for $\hat{a}_{Mt}$ and Equation (37) for $\hat{K}_t$, which yields

$$\varepsilon_0 (1 - \varepsilon_1 G_t) g_F = \tau_0 + \tau_K \varepsilon_0 (1 - \varepsilon_1 G_t) g_F + \tau_G G_t E_{Mt} (1 + \lambda \bar{m}) \tag{40}$$

Again we find that this contains only G and E_M, i.e., Equations (39) and (40) represent the core subsystem under the current assumptions of export-led growth (no government intervention). These two equations can be solved to yield

$$G^* = \frac{(\varepsilon_0 - 1)}{\varepsilon_0 \varepsilon_1} \tag{41}$$

$$E_M^* = \frac{(g_F(1 - \tau_K) - \tau_0)\varepsilon_0 \varepsilon_1}{\tau_G (\varepsilon_0 - 1)(1 + \lambda \bar{m})} \tag{42}$$

The first of these shows that $\varepsilon_0 \leq 1$ is not a valid case, because it implies $G^* \leq 0$, which is at odds with the setup of our model with South as the technologically lagging country. Therefore we can only have export-led growth with $G^* < 1$ when $\varepsilon_0 > 1$ and other parameter values compatible with $G^* = \frac{(\varepsilon_0 - 1)}{\varepsilon_0 \varepsilon_1} < 1$ and $0 < E_M^* = \frac{(g_F(1 - \tau_K) - \tau_0)\varepsilon_0 \varepsilon_1}{\tau_G (\varepsilon_0 - 1)(1 + \lambda \bar{m})} < 1$. Note that $\varepsilon_0 > 1$ is a theoretically unlikely assumption, because it implies that the elasticity of South's exports with respect to Northern income will be large, quite possibly > 1.

Ignoring this point, Equations (41) and (42) represent steady state values that result from the difference equations (39) and (40), and the growth rate of the Southern economy then becomes

$$\hat{K}^* = g_F \tag{43}$$

However, our numerical simulations indicate that this steady state is unstable, and that the technology gap either converges to $G^* = 0$, which we have already ruled out, or to $G^* = 1$, which is a case that we will examine below. While we are unable to provide a general proof that the steady state is unstable, we tried a range of parameter values that yield values in the interval $\langle 0..1 \rangle$ for Equations (41) and (42), and none of these converges to this steady state in numerical simulations. Also, with all of these parameter values, the Jacobian matrix of the core subsystem has eigenvalues > 1 when evaluated at the steady state, pointing to instability. In conclusion, we dismiss $\varepsilon_0 > 1$ as both theoretically inferior, and as leading to an unstable steady state. This makes the case of export-led growth with $G^* < 1$ a mere mathematical curiosity without economic relevance.

Export-led growth (no government intervention) with $G^* = 1$

We now consider the alternative solution to Equation (33), which is $G = 1$, while maintaining the assumption of no government intervention. Then Equation (37) still holds, but we must substitute $G^* = 1$:

$$\widehat{K}^* = \varepsilon_0(1 - \varepsilon_1)g_F \tag{44}$$

Equation (39) no longer holds, because we do not require $\widehat{T}_{St} = \widehat{T}_{Nt}$, but Equation (40) does apply in order to obtain a stable value E_M^*. We must then again substitute $G^* = 1$:

$$\varepsilon_0(1 - \varepsilon_1)g_F = \tau_0 + \tau_K \varepsilon_0(1 - \varepsilon_1)g_F + \tau_G E_{Mt}(1 + \lambda\overline{m}) \tag{45}$$

which immediately yields

$$E_M^* = \frac{\varepsilon_0(1-\varepsilon_1)(1-\tau_K)g_F - \tau_0}{\tau_G(1+\lambda\overline{m})} \tag{46}$$

Next, in the steady state, Equation (10) requires $\widehat{K}^* = h_t \frac{Y_t}{K_t} - \delta$, and since $\frac{Y_t}{K_t} = \frac{\mu}{v}$, we obtain

$$h^* = \left(\widehat{K}^* + \delta\right)\frac{v}{\mu} = (\varepsilon_0(1 - \varepsilon_1)g_F + \delta)\frac{v}{\mu} \tag{47}$$

Equation (8) immediately yields

$$u^* = \mu \tag{48}$$

This leaves the steady state values B^* and χ^* to be determined. Setting Equation (24) to zero yields

$$\chi_t = -B_t \widehat{K}^* \frac{1-c-h^*+\overline{m}}{1-c-h^*} \tag{49}$$

Next, we substitute Equation (20) into (22), and also using $\frac{Y_t}{K_t} = \frac{\mu}{v}$ and $m^* = \overline{m}$, this yields

$$\Delta B_t = \frac{1}{1+\widehat{K}_t}\left(\overline{m}\frac{\mu}{v} - \chi_t - \widehat{K}^* B_t\right) \tag{50}$$

Setting this to zero results in

$$\chi_t = \overline{m}\frac{\mu}{v} - \widehat{K}^* B_t \tag{51}$$

Finally, equating (49) and (51), we find

$$B^* = -\frac{\mu}{v}\left(\frac{1-c-h^*}{\widehat{K}^*}\right) \tag{52}$$

Substituting this back into Equation (51) yields

$$\chi^* = (1 - c - h^* + \overline{m})\frac{\mu}{v} \tag{53}$$

Box A1 collects all steady state values for the case of export-led growth with $G^* = 1$.

Box A1. Steady state values for export-led growth (no government intervention) with $G^* = 1$

$$u^* = \mu$$

$$h^* = \frac{v}{\mu}\left(\widehat{K}^* + \delta\right) = \frac{v}{\mu}(\varepsilon_0(1-\varepsilon_1)g_F + \delta)$$

$$\widehat{Y}^* = \widehat{K}^* = \widehat{a}_M^* = \varepsilon_0(1-\varepsilon_1)g_F$$

$$E_M^* = \frac{(1-\tau_K)\varepsilon_0(1-\varepsilon_1)g_F - \tau_0}{\tau_G(1+\lambda\overline{m})}$$

$$\zeta^* = 0$$

$$t^* = 0$$

$$D^* = 0$$

$$B^* = -\frac{\mu(1-c-h^*)}{v\widehat{K}^*}$$

$$\chi^* = \frac{\mu}{v}(1 - c - h^* + \overline{m})$$

$$m^* = \overline{m}$$

$$G^* = 1$$

Policy-led growth with $G^* < 1$

For the policy-led case, we must notice that our derivations so far were based on $\widehat{K}_t = \varepsilon_0(1 - \varepsilon_1 G_t)g_F$ (Equation 37), which is one of the alternative solutions to Equation (26). Together with other equations, $\widehat{K}_t = \varepsilon_0(1 - \varepsilon_1 G_t)g_F$ led to the alternative steady state values E_M^* that are specified in Equations (42) and (46). Now that the government implements a demand-led policy that will raise E_M to a level $\bar{E} > 0$, Equations (42) and (46) no longer hold. This means that in Equation (36), $\chi^* = 0$ must hold. Therefore, as we already announced, the case of government intervention raising E_M to the level $\bar{E}$ also implies that growth is no longer export-led.

This immediately changes the working of the foreign deficit variable B, for which Equation (27) now dictates $B^* = \bar{B}$. Accordingly, $m^* = \bar{m}$ will not hold anymore. To find the new steady state value m^*, we again substitute Equation (20) into (22), this time with $\chi^* = 0$ and $B^* = \bar{B}$, again use $\frac{Y_t}{K_t} = \frac{\mu}{v}$, and set the result to zero to obtain

$$m_t = \widehat{K}_t \frac{v\bar{B}}{\mu} \tag{54}$$

This leaves the steady state growth rate $\widehat{K}^*$ to be determined to find m^*. To find this, we use Equation (54) to write alternatives to Equations (39) and (40), with the result still forming the core subsystem of the model:

$$\tau_0 + \tau_K \widehat{K}_t + \tau_G G_t \bar{E}\left(1 + \lambda \widehat{K}_t \bar{B}\frac{v}{\mu}\right) = g_F \tag{55}$$

$$\widehat{K}_t = \tau_0 + \tau_K \widehat{K}_t + \tau_G G_t \bar{E}\left(1 + \lambda \widehat{K}_t \bar{B}\frac{v}{\mu}\right) \tag{56}$$

Equations (55) and (56) now only contain the variables $\widehat{K}_t$ and G_t, and they can be solved to yield the steady state solutions

$$\widehat{K}^* = g_F \tag{57}$$

$$G_t = \frac{g_F(1-\tau_K) - \tau_0}{\tau_G \bar{E}\left(1 + \lambda g_F \bar{B}\frac{v}{\mu}\right)} \tag{58}$$

Also the steady state value m^* can now easily be found by substituting Equation (57) into (54):

$$m^* = \frac{v\bar{B}}{\mu} g_F \tag{59}$$

The steady state value h^* doesn't change as a function of $\widehat{K}^*$, and also u^* doesn't change. This leaves the steady state values for the two government related variables, ζ^* and t^* to be determined.

Setting Equation (17) to zero, with $D^* = 0$ and $\frac{Y_t}{K_t} = \frac{\mu}{v}$ yields $\zeta_t = t_t \frac{\mu}{v}$ and Equation (25) with $\chi^* = 0$ can be rewritten to obtain $\frac{\mu}{v} = \frac{\zeta_t}{1-c(1-t_t)-h^*+m^*} \Rightarrow \frac{\mu}{v}(1 - c(1 - t_t) - h^* + m^*) = \zeta_t$, and by equating these two expressions, we obtain

$$t^* = 1 - \frac{h^*-m^*}{1-c} \tag{60}$$

and by substituting back

$$\zeta^* = t^* \frac{\mu}{v}\left(1 - \frac{h^*-m^*}{1-c}\right) \tag{61}$$

Box A2 collects all steady state values for demand policy-led growth with $G^* < 1$.

Box A2. Steady state values for policy-led growth with $G^* < 1$

$$u^* = \mu$$

$$h^* = \frac{v}{\mu}\left(\widehat{K}^* + \delta\right) = \frac{v}{\mu}(g_F + \delta)$$

$$\widehat{K}^* = \hat{a}_M^* = g_F$$

$$E_M^* = \bar{E}$$

$$\zeta^* = t^* \frac{\mu}{v} = \frac{\mu}{v} - \frac{(1-\bar{B})g_F + \delta}{1-c}$$

$$t^* = 1 - \frac{h^*-m^*}{1-c} = 1 - \frac{v}{\mu(1-c)}\left((1-\bar{B})g_F + \delta\right)$$

$$D^* = 0$$

$$B^* = \bar{B}$$

$$\chi^* = 0$$

$$m^* = \frac{v}{\mu}\bar{B}g_F$$

$$G^* = \frac{g_F(1-\tau_K) - \tau_0}{\tau_G \bar{E}(1 + \lambda m^*)} = \frac{g_F(1-\tau_K) - \tau_0}{\tau_G \bar{E}\left(1 + \lambda g_F \bar{B}\frac{v}{\mu}\right)}$$

Policy-led growth with $G^* = 1$

If, given parameter values, Equation (54) yields a value > 1, then Equation (51), which states $\widehat{T}_{St} = \widehat{T}_{Nt}$, no longer holds because the technology gap will converge to $G^* = 1$ in the steady state. This is the alternative solution for Equation (33). Instead of the growth rate of the Southern knowledge stock being equal to that in North, Southern knowledge now grows perpetually slower than North. Equation (56), on the other hand, still holds, and we can substitute $G = 1$

$$\widehat{K}_t = \tau_0 + \tau_K \widehat{K}_t + \tau_G \bar{E} \left(1 + \lambda \widehat{K}_t \bar{B} \frac{v}{\mu}\right) \tag{62}$$

This now readily solves for the steady state growth rate

$$\widehat{K}_t = \frac{\tau_0 + \tau_G \bar{E}}{1 - \tau_K - \tau_G \lambda \bar{E} \bar{B} \frac{v}{\mu}} \tag{63}$$

The derivation of the other variables does not change relative to the case of policy-led growth with $G^* < 1$, although we have to leave some of these steady state values as functions of $\widehat{K}^*$. Box A3 collects all steady state values.

Box A3. Steady state values policy-led growth with $G^* = 1$

$$u^* = \mu$$

$$h^* = \left(\widehat{K}^* + \delta\right)\frac{\upsilon}{\mu}$$

$$\widehat{K}^* = \hat{a}_M^* = \frac{\tau_0 + \tau_G \bar{E}}{1 - \tau_K - \tau_G \lambda \bar{E} \bar{B} \frac{\upsilon}{\mu}}$$

$$E_M^* = \bar{E}$$

$$\zeta^* = t^* \frac{\mu}{\upsilon}$$

$$t^* = 1 - \frac{h^* - m^*}{1 - c} = 1 - \frac{\upsilon}{\mu(1 - c)}\left((1 - \bar{B})\widehat{K}^* + \delta\right)$$

$$D^* = 0$$

$$B^* = \bar{B}$$

$$\chi^* = 0$$

$$m^* = \frac{\upsilon \bar{B}}{\mu} \widehat{K}^*$$

$$G^* = 1$$

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