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Transfer Problem Dynamics: Macroeconomics of the Franco-Prussian War Indemnity

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Abstract

We study the classic transfer problem of predicting the effects of an international transfer on the terms of trade and the current account. A two-country model with debt and capital allows for realistic features of historical transfers: they follow wartime increases in government spending and are financed partly by borrowing. The model is applied to the largest historical transfer, the Franco-Prussian War indemnity of 1871-1873. In these three years, France transferred to Germany an amount equal to 22 percent of a year's GDP. When the transfer is combined with measured shocks to fiscal policy and a proxy for productivity shocks over the period, the model provides a very close fit to the historical sample paths of French GDP, terms of trade, net exports, and aggregate consumption. This makes a strong case for the dynamic general equilibrium approach to studying the transfer problem.

JEL classification: F32, F41, N14

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1. Introduction

What are the economic effects of a unilateral transfer of resources between countries? In textbooks on international economics, this question is referred to as the 'transfer problem'. Transfers were an endemic feature of economic history (at least until the 1930s); they typically followed wars, and were imposed by the victors on the defeated party. Although the debate on the transfer problem goes back to the 19th century, the best known reference is the Keynes-Ohlin controversy in the 1929 *Economic Journal* concerning the impact of German reparation payments after the 1914-18 War.

The study of large transfers is of interest for two main reasons. First, understanding the response to a transfer should shed light on the way to build models in open-economy macroeconomics. Transfers represent large shifts in wealth between countries within a short time period. They thus represent experiments that can be used to test models of international economics. For example, the response of the current account to the transfer may help us assess the intertemporal approach to the current account or the related question of how to model market incompleteness or limits on international risk-sharing. Similarly, the response of prices to the transfer should be informative about general equilibrium models of the terms of trade.[1]

Second, as we have noted, transfers played an important role in economic history. In this study, we focus on the largest transfer in history; the Franco-Prussian War indemnity payment of 1871-73. The indemnity was blamed by popular historians for everything from the German stock market crash of 1873 to slow population growth in France. Since transfers generally followed wars, identifying the economic effects of the transfer or reparations requires that we control for other shocks, such as those to government spending during wartime.

Despite the empirical prevalence of transfers, most of the literature on the trans-

[1] A standard reference on the intertemporal approach to the current account is Obstfeld and Rogoff (1995). See Backus, Kehoe and Kydland (1994a,b) for modelling terms of trade movements.

fer problem has been theoretical, and set in the context of simple, static models of international trade. Many studies focus on relatively narrow, qualitative questions regarding the impact of the transfer on welfare of the donor or the recipient. Since the traditional models tend to ignore many channels through which transfers may operate, such as endogenous output, capital accumulation, and international capital markets, they do not easily allow for an explicitly quantitative investigation of transfers. Although much has been written about the transfer problem in general, and the Franco-Prussian war indemnity payment in particular, to the best of our knowledge, there have been no quantitative historical studies of the macroeconomic effects of transfers, and certainly none that uses an intertemporal general equilibrium method.

This paper studies the transfer problem using an open-economy, dynamic general equilibrium model, in which we look at a transfer in combination with other shocks. Within this framework, transfers can have a rich series of effects, depending on the sectoral structure of the economy, the assumptions about labor supply and investment technology, and the degree of access to international capital markets. Our principal focus is on the quantitative impact of a transfer.

Using data from France during the 1860s and 1870s, we document the historical evolution of the key macroeconomic aggregates, including GDP, net exports, and the terms of trade. We also are able to isolate some of the key shocks during this period, including – but not exclusively – the transfer payment shock. While the transfer represented a huge macroeconomic shock to the French economy, the evidence suggests that there were other large shocks at the time. We identify shocks to government spending (fiscal policy) and a proxy variable for aggregate productivity. Using these shocks, we can construct model-generated sample paths of the French economy.

The model is very successful in accounting for the historical sample paths of the main macroeconomic aggregates. But the transfer shock cannot do this alone. On its own, the transfer shock can account quite well for the movements in the terms of trade and net exports, but it cannot provide an adequate account of the paths of GDP and aggregate consumption. On the other hand, fiscal policy and the productivity proxy shocks provide a reasonable account of the paths of GDP and consumption, but fail to account for the movements in the terms of trade and net exports in the 1871-1874 period. When we combine the transfer shock and fiscal and productivity shocks however, we find that the model does a good job in accounting for all these macroeconomic aggregates.

Section 2 gives background and sources for previous research on the transfer problem. Section 3 explains why we adopt the Franco-Prussian War indemnity for study, and gives some associated history. Section 4 develops a static, two-country model of the effects of the transfer on the terms of trade and consumption. This setup introduces much of the notation and is in keeping with most of the theoretical work on the transfer problem. Next, section 5 introduces debt and capital. Section 6 contains numerical results from the dynamic model, and compares its sample paths to those from history. Section 7 contains a discussion of other shocks. Section 8 comments on the evidence of the transfer's effects in Germany. Section 9 concludes.

2. Research on the Transfer Problem

J.S. Mill (1844) predicted that a transfer-paying country would experience a deterioration in its terms of trade, thus adding to the burden of the transfer. Keynes (1929) elaborated, arguing that the donor government's increase in supply through the non-market transfer drives down the price of its exports. Ohlin (1929) called this the 'orthodox' view and argued that it might not hold because of income effects. The recipient is richer as a result of the transfer and so spends more on the donor's goods. The donor is poorer and so spends less on the recipient's goods. So the donor's terms of trade may improve. But Samuelson (1952) proved that the orthodox view was theoretically correct. In a competitive, two-good, two-country world the donor's terms of trade deteriorate iff its marginal propensity to consume its export good is greater than that of the recipient.

The large literature on the transfer problem, completely reviewed by Chipman (1974) and Brakman and van Marrewijk (1998), is generally static and theoretical. It is concerned with factors such as distortions, third parties, public goods, or tied aid. In this research, intertemporal trade is generally ruled out. But historical transfers often were financed through borrowing, rather than paid from current national income. In the original debate on the transfer problem, for example, Angell (1930) reviewed prospects for German reparations and their finance by international borrowing. Relative to the large literature on the transfer problem, our modeling approach is very benign when it comes to the array of goods and preferences. Instead, we investigate changing the constraints and technology to allow endogenous output, lending and borrowing, and capital accumulation.

Several papers have examined some implications of international borrowing. Brock (1996) studied transfer problem dynamics and allowed for borrowing. He considered a small open economy with fixed terms of trade, and so focused on the adjustment of the relative price of non-traded goods. Obstfeld and Rogoff (1996) discussed the transfer problem in a model of transport costs and non-traded goods, and argued that this framework supports the orthodox view of the effects of a transfer. Obstfeld and Rogoff (1995) emphasized a different mechanism, coming from the wealth-induced expansion in labor supply resulting from a transfer, which leads to a terms of trade deterioration for the donor. Both of these latter mechanisms are integral to our dynamic model below.

The original commentators on the transfer problem, such as Rueff (1929), emphasized the role of the terms of trade, so we adopt a two-country model and make that endogenous. Ritschl (1998) used Keynesian import equations to empirically study the effects of credit constraints implied by the Young Plan on Germany after 1929. White (2001) studied the reparations paid by France after the Napoleonic Wars from the perspective of the intertemporal approach to the current account. He concluded that consumption was smoothed through international borrowing, but not by as much as predicted by theory. He also used a neoclassical growth model to estimate the costs of various ways of financing that transfer.

Finally, this work also is part of more general research on the determination of the terms of trade and the real exchange rate. Lane and Milesi-Ferretti's (2000) empirical work suggests links between external liabilities and the real exchange rate. Our empirical work seeks to isolate the effects of a specific shock – like reparations – to net foreign assets.

As mentioned in the introduction, empirical work on the transfer problem is rare. But two studies have estimated some of the effects of the Franco-Prussian War indemnity. Lévy-Leboyer and Bourguignon (1990, pp 243-247) studied the effects of both the war and the indemnity by adjusting and simulating an estimated, econometric model. Gavin (1992) suggested that consumption smoothing (the intertemporal approach to the current account) was relevant, but did not formally apply that approach. He used trends to assess the effects of the transfer on French and German saving and investment during the 1870s.

3. The Franco-Prussian War Indemnity

This transfer is an ideal candidate for study. It was paid virtually as a lump sum, was of a large scale, was successfully made, and was largely free of default risk. The transfer took place in an environment of relatively free international capital markets. Data on the terms of trade and on macroeconomic aggregates are available for France and some of its trading partners for this period.

After the Franco-Prussian War, France owed Germany an indemnity of 5 billion francs. Under the Treaty of Frankfurt, France agreed to pay this amount by 1 March 1875. Appendix A to this paper contains the relevant article of the treaty. In fact, most of the money was raised through two domestic bond issues in 1871 and 1872, which were heavily over-subscribed. Payment was complete during 1873. As Kindleberger (1993, p 245) noted:

> Particularly noteworthy in the light of the subsequent transfer problem with German reparations after World War I was that with no Keynes to tell them that transfer was impossible, the recycling and subsequent real transfer took place without any banker, economist, or government official giving thought to the question of whether the transfer was feasible.

The transfer consisted of bills of exchange and to a lesser extent gold, silver, and bank notes. The purchase of these bills was financed by the issue of callable perpetuities. Many of these bonds were purchased by foreigners, and many French foreign asset holdings also were sold. Monroe (1919) gave a detailed description of the timing, source, and composition of payments.

According to Brakman and van Marrewijk's measurements (1998, table 1.7) this payment was the largest transfer in history, amounting to almost 23 percent of a year's GDP or two and a half times the annual government budget in France. In contrast, the German reparations payments of the 1920s amounted to about 2.5 percent of GDP, the Finnish transfers to the USSR in the 1940s to 4 percent of GDP, and the transfers from the former West to East Germany in the early 1990s to 4.25 percent of GDP. The Franco-Prussian indemnity was also large as a share of the recipient's GDP, for in 1870 Prussian/German GDP was only slightly greater than that of France.

The only comparable transfer was again made by France, but in 1815 after the Napoleonic Wars. White (2001, table 5) shows that these reparations were 18-21 percent of GDP but constituted a larger share of exports than the indemnity of 1871. They also were a very large burden because they took place at a time of high real interest rates. We do not study this transfer because it took place over a longer time period (1815-1819) and because measures of the terms of trade and consistent national accounts are not available for that period.

Aside from the scale and pace of the transfer, the 1871 indemnity is notable also because there was virtually no sovereign debt risk associated with it. The timetable for the withdrawal of Prussian troops from French territory was explicitly linked to indemnity payments. Adolphe Thiers, the president of the republic from 1871 to 1873, was committed to early payment of the indemnity and was acceptable to Bismarck partly for that reason.

Most of the economic history on the indemnity has to do with the financial aspects rather than the macroeconomic effects. For example, Say (1898), Kindleberger (1993), and Landes (1982) discussed the financial arrangements for the transfer. But some historians have debated the economic costs to France of the indemnity and whether the German boom of the early 1870s can be attributed to the transfer. Eagly (1967) described the widespread view that the post-1873 depression was more severe in Germany than in France *and* that this difference was caused by the indemnity. He called this the ‘potlatch’ theory. In France, a rumour circulated that Germany was considering returning the indemnity.

Monroe (1919) presented some data which suggested that the German recession after 1873 was relatively severe. Norman Angell’s 1913 best-seller, *The Great Illusion*, argued for the futility of reparations – and the Franco-Prussian War indemnity in particular – and of military power and conquest more generally. More thorough research on Germany has shown that its recession probably was no more severe than in other countries. O’Farrell (1913) argued that the mid-1870s business cycle was worldwide. Eagly gave data on output in several sectors (coal, iron) and showed that in real terms the German recession was in fact slightly milder than the French one. Even the stock market boom in Germany may have been due to an easing of incorporation laws, rather than to the indemnity. Unfortunately, German macroeconomic data for the 1870s remain incomplete, as Fremdling (1995) argues. While these works have debated the macroeconomic data for Germany, they have not been concerned with formally modeling the effects of the transfer.

The historical record for France can best be seen through some time series graphs. The dark line in Figure 1 shows France’s annual current account balance as a share of GDP. Consistent data are available thanks to the achievement of Lévy-Leboyer and Bourguignon (1990); details are given in Appendix B. In the years before the transfer, France ran a current account surplus, averaging roughly 5 percent of GDP.

Next, we use the indemnity payments estimated by Lévy-Leboyer (1977): 1.435 billion F in 1871, 1.801 billion F in 1872 and 2.295 billion F in 1873, or 7.24%, 8.68%, and 11.1% of GDP. Adding these to the the current account balance shows the balance net of the indemnity. As a share of GDP, this net figure is shown in the dotted line in Figure 1. Clearly the indemnity was greater than the other components of the current account during those years, so a significant part of it was financed by selling assets or by borrowing internationally. Both saving and investment, as shares of GDP, fell sharply from 1870 to 1871, but savings recovered more rapidly, as is also reflected in the current account series in Figure 1. Gavin (1992) drew attention to these separate changes in saving and investment and their contributions to post-war current account surpluses.

Much of the theoretical work on the transfer problem has focused on the effect of a transfer on the terms of trade of the donor and of the recipient. The terms of trade is defined as the ratio of import prices to export prices: $s \equiv p_m/p_x$. Figure 2 shows the French terms of trade (solid line) and the trade balance as a share of GDP (dashed line). The figure shows that the French terms of trade deteriorated during the early 1870s, as predicted by the orthodox view of international transfers (and, for the 1920s, by Keynes).

The theory applies to *per capita* measures, and so we deflate quantities using Mitchell's (1998) mid-year population estimates. In many applications, this transformation would not matter, for French population stagnated during this period, growing by only 0.36% per year from 1861 to 1866 and by 0.54% per year from 1872 to 1876. In this case, though, we need to adjust for the loss of Alsace and Lorraine in 1871, as the Mitchell data do. Those regions comprised roughly 4% of French population.

Figure 3 shows estimates of the paths of real, *per capita* output, consumption, and government spending for France. These series are measured by dividing the nominal series by the cost of living and the population series. The solid line is real output, while the dotted line gives a measure of aggregate consumption. Both series dropped sharply during the war, then recovered even as the indemnity was being paid. Output was disrupted by the occupation and loss of Alsace-Lorraine, by the siege of Paris, by the Paris Commune, and by the political uncertainty associated with the founding of the Third Republic. Figure 3 suggests that the degree of consumption smoothing in fact was very limited, as the path of real consumption parallels that of real output. This evidence seems inconsistent with the intertemporal approach to the current account. Again, however, a complete model is needed to assess whether this path for consumption is consistent with a standard model of budgeting. In assessing the effects of the transfer, we later control for other shocks, such as the wartime jump in government spending, which also is shown in Figure 3 (dashed line).

4. Preferences, Goods, and an Exchange-Economy Example

To estimate the quantitative effects of the transfer, we begin with a static, exchange economy model. Most traditional, theoretical models of the transfer problem are static. This exercise sets a standard of comparison, so that we can later show the effects of current account dynamics and endogenous production. In addition, the static model introduces much of the notation used in the paper.

Two regions are denoted home (France) and foreign (the world minus France but including Germany). The foreign economy is the rest of the world because France could finance the transfer by borrowing from third countries and because its net exports and terms of trade data are relative to the rest of the world rather than with Germany. Foreign variables are labelled with an asterisk. We normalize so that the world population is unity. Then we let the French population constitute a proportion ω of the world economy. Each agent has an endowment of a country-specific good: x in France and m abroad. Consumption of a good in France is denoted c_i, $i \in \{x, m\}$. France imports c_m and exports c_x^*.

Market clearing in the two traded goods implies that domestic consumption and foreign purchases exhaust output each period:

$$\begin{aligned} x &= c_x + \left(\frac{1-\omega}{\omega}\right) c_x^* \\ m &= \left(\frac{\omega}{1-\omega}\right) c_m + c_m^*. \end{aligned} \tag{1}$$

Let s be the French terms of trade, expressed as the ratio of import prices to export prices. Without lending and borrowing, trade must balance each period, including a transfer T:

$$\left(\frac{1-\omega}{\omega}\right) c_x^* = s\, c_m + T. \tag{2}$$

An increase in the transfer requires an equal increase in the French trade surplus.

French consumers consume an aggregate c composed of domestic goods and imports. This aggregate is given by:

$$c(c_x, c_m) = [\mu^{\frac{1}{\lambda}} \omega^{\frac{1}{\lambda}} c_x^{1-1/\lambda} + (1-\omega)^{\frac{1}{\lambda}} c_m^{1-1/\lambda}]^{\frac{\lambda}{\lambda-1}}, \tag{3}$$

so that λ is the elasticity of substitution and $\mu > 1$ indicates a preference for home goods. The population weight ω enters this definition because country size determines the share of a country's consumption that comes from home goods. Foreign consumption is of the same form.

In France, utility maximization yields:

$$\mu^{\frac{1}{\lambda}} \left(\frac{\omega}{1-\omega}\right)^{\frac{1}{\lambda}} \left(\frac{c_x}{c_m}\right)^{-\frac{1}{\lambda}} = \frac{1}{s} \tag{4}$$

and in the rest of the world:

$$\mu^{\frac{1}{\lambda}} \left(\frac{\omega}{1-\omega}\right)^{-\frac{1}{\lambda}} \left(\frac{c_m^*}{c_x^*}\right)^{-\frac{1}{\lambda}} = s. \tag{5}$$

Given endowments x and m and a transfer T, equations (1), (2), (4) and (5) determine consumptions c_x, c_m, c_x^*, c_m^*, and the terms of trade s. As an example, suppose there is no preference for home goods, so that $\mu = 1$. Then $s = (x/m)^{\frac{1}{\lambda}}$. As in Backus, Kehoe, and Kydland (1994b) for example, the terms of trade depend only on the endowment ratio. There is no transfer effect on the terms of trade.

Any preference for home goods ($\mu > 1$) implies that a transfer leads to a deterioration of the French terms of trade (a rise in s). The rest of the world consumes more of its own export good, good m, with the transfer than France would have done, so the relative price of foreign goods rises and the French terms of trade deteriorate. For non-Cobb-Douglas preferences there is no analytic solution. Brakman and van Marrewijk (1998, chapter 3) provide a proof that home bias leads to a deterioration in the donor's terms of trade and a lucid discussion of the general static model. Note that country size in itself does not matter for the level of the terms of trade, because a rise in ω increases both the relative supply of French goods, and the relative weight of French consumers.

Before describing the model's quantitative predictions, we also allow for non-traded goods. These were clearly important in France and its trading partners during the 1870s. For example, agriculture, services, transport, and government made up almost two-thirds of French GDP in 1870. While agriculture includes goods such as silk and wine that were traded internationally, these sectors also include a large non-traded component.

Non-traded goods also played a role in the original Keynes-Ohlin debate on the terms of trade. Ohlin (1929) argued that the presence of non-traded goods – and the possibility of changes in the internal terms of trade – influences the required changes in the international terms of trade. But Chipman (1974) proved that the orthodox view continues to hold if each country specializes in the production of its exportable good and a nontraded good. He showed that this result holds in a pure exchange economy or in a two-factor production economy with homothetic preferences. Our environment features this specialization in the endowment or production of traded goods, so the issue we study will be the scale of the terms-of-trade change, not the sign.

Now suppose France has an endowment n of non-traded goods, while the foreign economy has an endowment n^*. French consumption is an aggregate of traded goods c_T and non-traded goods c_N:

$$c = [\gamma^{\frac{1}{\theta}} c_T^{1-\frac{1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} c_N^{1-\frac{1}{\theta}}]^{\frac{\theta}{\theta-1}}, \tag{6}$$

where the consumption of traded goods remains a composite of French and foreign traded goods as written in equation (3).

The consumer price index is:

$$p = [\gamma p_T^{1-\theta} + (1-\gamma) p_N^{1-\theta}]^{\frac{1}{1-\theta}}. \tag{7}$$

The consumption-based price index of traded goods is:

$$p_T = [\mu\omega + (1-\omega) s^{1-\lambda}]^{\frac{1}{1-\lambda}}. \tag{8}$$

The French budget constraint now is:

$$pc = x + p_N n - T, \tag{9}$$

where the transfer T is measured in traded goods and p_x is normalized to one.

Now the internal terms of trade, the relative price of traded to non-traded goods, is given by:

$$\left(\frac{\gamma}{1-\gamma}\right)^{\frac{1}{\theta}} \left(\frac{c_T}{c_N}\right)^{-\frac{1}{\theta}} = \frac{p_T}{p_N}. \tag{10}$$

The non-traded good is given by an endowment n, so that

$$c_N = n. \tag{11}$$

Market-clearing conditions for traded goods (1) continue to apply.

Similar conditions apply in the starred, rest of the world except that their preference over goods x and m is the reverse of that of the French. Then the model's equations can be solved for the nine unknowns: s, p_N, p_N^*, c_N, c_N^*, c_x, c_x^*, c_m, and c_m^*, and the consumption of individual goods may be aggregated to give aggregate consumption.

We next set parameter values so as to provide a numerical example. France's share of world GDP is $\omega = 0.165$ (based on France's share of GDP in the developed world in 1870, estimated from Maddison 1991, tables 1.1 and B.1). The ratio of exports to GDP for France in 1870 was 15 percent. Given the other parameter settings, the value of μ which reproduces this ratio is 6.5. The elasticity of substitution between traded exports and imports is $\lambda = 1.5$. This is the same number used by Backus, Kehoe, and Kydland (1994a) and similar to that of Heathcote and Perri (2003).[2] The elasticity of substitution between traded and non-traded goods is set at $\theta = 0.75$.

[2] There is some debate about the value of this elasticity. Ruhl (2003) argues that the aggregate, measured elasticity in response to permanent changes in relative prices may be much higher than this value, due to endogenous entry into the export sector. But at business-cycle frequencies, as in our study, he estimates an elasticity of 1.4.

Allowing for some traded component of the agriculture sector, we use an estimate of the non-traded goods sector at 50 percent of GDP, so we set $\gamma = 0.5$.

Table 1 gives some results from the static model, and compares them with evidence for France. The table shows the model's predictions for the changes in the terms of trade and consumption. We make three calculations. First, we impose a transfer of 7.2 percent of GDP, the actual transfer paid in 1871 as a proportion of 1870 GDP. Second, we look at the payment of the full transfer, equal to 22 percent of GDP. Third, to offer a realistic comparison with the dynamic model, which allows borrowing, we study the impact of a transfer equal to rT, or the annuity value of the full transfer, where r represents the real interest rate used to construct the annuity (we assume $r = 0.05$). The logic of this final experiment is that even in the absence of explicit international capital markets, the transfer from the donor to the recipient country may be brought about by a permanent flow payment equal to the annuitized value of the full transfer.

The model's predictions can be compared to the evidence for France in the lower rows of Table 1, for the data represent the terms of trade with the rest of the world, rather than with Germany. The first two calculations predict greater deterioration in the terms of trade than took place in the historical record. For the 7.2 percent transfer, the predicted fall in consumption is roughly the same as the 1870-71 consumption decline. For the full immediate transfer, though, consumption is predicted to fall by much more than the historical fall.

The third calculation (the annuitized transfer), predicts too small a deterioration in the terms of trade and predicts virtually no fall in consumption. While French consumption fell from 1870 to 1871, it then grew in subsequent years while the transfer was being paid.

The static model is missing several adjustment mechanisms, including explicit borrowing, investment, and employment. It also is missing other shocks. Figure 2 shows large movements in the French terms of trade during other years, when transfers did not occur. We need to identify other shocks to explain those fluctuations, and so must control for those shocks to try to isolate the effects of the transfer. But the effects of other shocks – like those to government spending or productivity – depend on their persistence. We thus need a dynamic model to study the impact of the transfer and, more generally, to study historical sample paths.

5. International Debt and Capital Dynamics

In this section we extend the model to allow for international debt, physical capital accumulation, and variable labor supply. Let household preferences be given by:

$$U = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} + \eta \frac{(1-h_t)^{1-\nu}}{1-\nu} \right), \tag{12}$$

with σ, $\nu > 0$ and as before $c = c(c_T, c_N) = c(c_x, c_m, c_N)$. The discount factor, β, is common across countries. Households consume a composite goods bundle and supply labor, h_t.

Bonds, b_t, are the only internationally traded asset. Therefore households in France cannot diversify away the income effects of a transfer. The higher French tax burden caused by the transfer must be fully met by French tax-payers. This asset-market incompleteness gives rise to real effects from the transfer, and also is realistic given the well-known home bias in investment portfolios.

As in section 4, the domestic export good is the numeraire, so $p_{xt} \equiv 1$. International bonds are denominated in domestic exports. The consumer purchases the composite consumption good, c_t, and invests in capital in the export sector, k_{xt}, and in the non-traded sector, k_{nt}. The return on international bonds, r_t, is denominated in domestic exports. Taxes collected by the government are given by τ_t. The real wage is w_t. The budget constraint for French households thus is:

$$p_t c_t + b_{t+1} + p_t i_{xt} + p_t i_{Nt} = w_t h_t + r_{xt} k_{xt} + r_{Nt} k_{Nt} + (1 + r_t) b_t - p_t \tau_t. \tag{13}$$

The deprecation rate is δ. Capital accumulates according to:

$$k_{xt+1} = \phi\left(\frac{i_{xt}}{k_{xt}}\right) k_{xt} + (1-\delta) k_{xt}, \tag{14}$$

and

$$k_{Nt+1} = \phi\left(\frac{i_{Nt}}{k_{Nt}}\right)k_{Nt} + (1-\delta)k_{Nt}. \tag{15}$$

In this technology, $\phi' > 0$, $\phi'' < 0$, and $\phi(\delta) = \delta$. This captures adjustment costs of capital that prevent capital moving between sectors and across borders with unrealistic speed.

In an optimal consumption plan, traded goods consumption is divided among domestic and foreign goods as:

$$c_{xt} = \mu\omega\left(\frac{1}{p_{Tt}}\right)^{-\lambda} c_{Tt}, \tag{16}$$

and

$$c_{mt} = (1-\omega)\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda} c_{Tt}. \tag{17}$$

Total consumption is divided among traded and non-traded goods as:

$$c_{Tt} = \gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta} c_t, \tag{18}$$

and

$$c_{Nt} = (1-\gamma)\left(\frac{p_{Nt}}{p_t}\right)^{-\theta} c_t. \tag{19}$$

Saving decisions stem from the usual Euler equations:

$$\beta \mathrm{E}_t\left[\frac{p_t c_t^{\sigma}(1+r_{t+1})}{p_{t+1}c_{t+1}^{\sigma}}\right] = 1. \tag{20}$$

Hours worked are chosen to satisfy:

$$\eta(1-h_t)^{-\nu} = c_t^{\sigma}\frac{w_t}{p_t}. \tag{21}$$

Capital in the export sector is chosen according to:

$$q_{xt}c_t^{-\sigma} = \mathrm{E}_t\beta c_{t+1}^{-\sigma}\left[\frac{r_{xt+1}}{p_{t+1}} + (1-\delta)q_{xt+1}\right] \tag{22}$$

where $q_{xt} = 1/\phi'(i_{xt}/k_{xt})$ is the real price of a unit of capital in the export sector, in terms of the composite good, and r_{xt+1} is the rental rate on capital in the export sector. A similar relationship holds in the non-traded sector, with real price q_{Nt}.

Firms face a static optimization problem, and simply maximize profits. Production functions are Cobb-Douglas, with capital share α in the export sector and κ in the non-traded sector. The profit-maximizing conditions for the two sectors are:

$$\begin{aligned} r_{xt} &= \alpha k_{xt}^{\alpha-1} h_{xt}^{1-\alpha} \\ w_t &= (1-\alpha) k_{xt}^{\alpha} h_{xt}^{-\alpha} \\ r_{Nt} &= p_{Nt} \kappa k_{Nt}^{\kappa-1} h_{Nt}^{1-\kappa} \\ w_t &= p_{Nt}(1-\kappa) k_{Nt}^{\kappa} h_{Nt}^{-\kappa}. \end{aligned} \tag{23}$$

For simplicity, we assume that the government finances a transfer and government spending with a lump-sum tax. Its budget constraint is:

$$p_t g_t + T_t = p_t \tau_t. \tag{24}$$

The implicit assumption here is that government spending falls across sectors in the same proportion as private spending. We cannot test this assumption directly, but Fontvielle (1976, table xv) showed that a large part of the wartime increase in public expenditure could be attributed to salaries.

Following recent numerical methods in open-economy macroeconomics, developed by Schmitt-Grohé and Uribe (2003) and Kollmann (2002), we assume that there is a debt-elastic differential between the home and foreign rates of interest. Thus, denoting the foreign rate of return (in terms of good x) as r_t^*, and French net foreign assets by b_t, the relationship between French and world interest rates is given by

$$(1 + r_{t+1}) = (1 + r_{t+1}^*)\psi(b_{t+1} - \bar{b}) \tag{25}$$

where the function $\psi(b_{t+1} - \bar{b})$ satisfies $\psi(0) = 1$, and $\psi' < 0$. This function captures the idea of an upward-sloping supply curve of foreign credit. When the economy is a net borrower, it faces an interest rate that is higher than the interest rate of its trading partner. When it is a lender, it receives an interest rate that is lower than that of the other country.

This specification (25) plays two roles. First, from a technical viewpoint, it eliminates a unit root in the world wealth distribution, because $\bar{b}$ represents a steady-state level of net foreign assets for the home country. Second, it captures the presence of 'frictions' in the international capital markets. As these frictions become larger and larger, captured by a larger absolute value of ψ', the effect of the transfer is more and more contained within the period of the transfer, and the use of international capital markets to smooth out the impact of the transfer is reduced. As Schmitt-Grohé and Uribe (2003) show, this friction has an effect on the response of an open economy that is essentially identical to a number of alternative methods for dealing with a unit root in the wealth distribution, such as assuming endogenous time preference or adjustment costs of international bond purchases. Empirically, Lane and Milesi-Ferretti (2001) have estimated a negative relationship between real interest rate differentials and net foreign assets for a panel of industrial and developing economies between 1971-1998.

The model is completed with market-clearing conditions. In each country, labor can be allocated to the non-traded sector or to the traded sector:

$$\begin{aligned} h_t &= h_{xt} + h_{Nt} \\ h_t^* &= h_{mt}^* + h_{Nt}^*. \end{aligned} \tag{26}$$

The non-traded goods market clears in each country:

$$\begin{aligned} k_{Nt}^{\kappa} h_{Nt}^{1-\kappa} &= (1-\gamma)\left(\frac{p_{Nt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ k_{Nt}^{*\kappa} h_{Nt}^{*1-\kappa} &= (1-\gamma)\left(\frac{p_{*Nt}}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*). \end{aligned} \tag{27}$$

Markets for each traded good clear:

$$\begin{aligned} k_{xt}^{\alpha} h_{xt}^{1-\alpha} = {} & \mu\omega\left(\frac{1}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ & + (1-\omega)\left(\frac{1}{p_{Tt}^*}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}^*}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*) \\ k_{mt}^{*\alpha} h_{mt}^{*1-\alpha} = {} & \omega\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ & + \mu(1-\omega)\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}^*}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*). \end{aligned} \tag{28}$$

An equilibrium determines the time path of interest rates, relative prices of non-traded goods, the terms of trade, and wages, as well as the consumption, capital, employment for each country, and net foreign assets.[3] Sections 6 and 7 next study the effects of the transfer on France in this dynamic economy.

6. Effects of a Transfer

In the dynamic model, there are additional parameter values that need to be determined. Table 2 describes the calibration. For many of the parameter values, we have no sources pertaining to France, Germany and the other industrial countries in the 1870s, so we simply follow the common parameter assumptions of the international macroeconomics literature. For instance, we assume that the labor share of output in each sector is 0.64, and that the common rate of depreciation of physical capital is 10 percent in each sector. We assume that the elasticity of intertemporal substitution in consumption is 1 (so that $\sigma = 1$) and that $\beta = 0.94$ so that the steady-state real interest rate is 6 percent. There is a range of estimates for the elasticity of substitution between export and import goods. We follow Backus, Kehoe, and Kydland (1994a) in setting $\lambda = 1.5$. Estimates of the elasticity of substitution between non-traded and traded goods, θ, also vary considerably. Stockman and Tesar (1994) estimate an elasticity of 0.44, while Burstein, Neves, and Rebelo (2003) use a value of θ equal to unity. As an intermediate setting, we follow Ostry and Reinhart (1992), who report an estimate $\theta = 0.75$. Our results are generally not sensitive to variations in this elasticity. The parameter $\gamma = 0.5$ determines the observed share of expenditure falling on non-traded goods in the French economy. As before, $\mu = 6.5$ replicates the export/GDP ratio for France.

We calibrate capital adjustment costs so that the elasticity of Tobin's q in each sector with respect to the investment-capital ratio is 0.3, following recent literature (*e.g.* Bernanke, Gertler, and Gilchrist, 2000). We estimate that in 1870, French net

[3] In principle, the small implicit costs associated with capital market frictions described in equation (25) should come out of domestic or foreign resources. But since we take a linear approximation around a steady state with r=r^*, these costs do not appear in the solution, so we ignore them in the description of the model.

foreign assets were 60 percent of GDP. Thus, for the function $\psi(b_{t+1} - \bar{b})$, we calibrate so that in a steady state, $\bar{b}$ is 60 percent of steady-state GDP. Then we may approximate (25) as

$$r_t = r_t^* - \chi b_t \tag{29}$$

Estimates of the parameter of the 'risk-premium', χ, also vary. Lane and Milesi-Ferretti's estimates suggest a value of $\chi = 0.001$. Using a different approach, Schmitt-Grohé and Uribe's (2003) estimates translate into $\chi = 0.01$. A similar number is used by Benigno (2002).

We also sought to estimate χ using an international interest-rate differential. For France the real interest rate r was measured as the annual average yield on 3% *rentes* minus the previous year's growth rate in the cost of living. The foreign real interest rate r^* was the rate on 3% British consols, with lagged cost-of-living inflation again included to capture expected inflation. Sources are given in appendix B. We then constructed a linear regression of this real-interest differential for 1860-1880 on real net foreign assets, as measured by Lévy-Leboyer (1977). During the early 1870s the interest differential widened and net foreign assets fell, which is consistent with a negative value for χ. But the estimated value for the coefficient was both insignificant and unstable across sub-samples. Lévy-Leboyer and Bourguignon (1990, p 192) estimated this elasticity using some additional controls, but also reported unstable (though negative) estimates.

Given the instability from this additional source of information, we use the value $\chi = 0.01$, a value used in some recent studies of twentieth-century data. One can think of our approach then as asking whether a model with minimal, late-twentieth-century frictions in the capital market can fit these nineteenth-century data. However, we also varied the value of χ and studied the fit of the model. The results show that the model with $\chi = 0.01$ fits French data quite well, so this sensitivity exercise can be thought of as an informal econometric estimator. But of course matching sample paths can still serve as a test of the model. In other words, we cannot rig the results by judicious choice of χ. There is ample overidentification as we compare the model and historical data for several variables and for multiple years.

The model is solved by linear approximation around an initial steady state. Linear approximation in principle may be inappropriate given a transfer of this magnitude, but previous research has established that dynamic constant-returns-to-scale economies of this type are quite 'smooth', so that the true dynamic solution behaves in an approximately linear fashion.

We now focus on the impact of an unanticipated transfer from France to Germany. From section 3, the estimates of the actual payments made, as a percentage of GDP, were 7.24, 8.68, and 11.1, in 1871, 1872, and 1873, respectively. We introduce this shock in the model as follows. In 1871, a previously unanticipated transfer of 7.24 percent of GDP is made, but agents then forecast accurately the payments of 8.68 and 11.1 percent of GDP for the succeeding two years. Because the terms of the full indemnity payment were imposed in 1871, clearly agents were able to forecast the occurrence of future payments. While the time path of payments may not have been fully predicted in 1871, in the presence of international capital markets, the time path of payments is approximately irrelevant (and exactly irrelevant when $\chi = 0$).[4]

The solid lines in Figure 4 illustrate the impact of the transfer in the baseline model. The figure shows the impulse response patterns for GDP, the terms of trade, the trade balance-GDP ratio, and consumption. The responses for GDP, the terms of trade, and consumption are measured in percentage points, while the response for the trade balance-GDP ratio is in levels.

Figure 4 shows that the the trade balance improves by about 3 percent of GDP. Since this falls short of the transfer made in 1871, the current account balance, including the transfer, must fall, as the economy runs down foreign assets to finance the

[4] Some transfer may have been expected during 1870 as the outcome of the war became clear, for Prussia had demanded indemnities from Austria and several south German states during the 1860s. Contemporary sources described the scale of the actual indemnity demanded in 1871 as many times greater than expected, though, so we treat the transfer as a surprise.

transfer. The improvement of the trade balance is generated by a fall in domestic consumption and a rise in domestic output. Output rises because the fall in consumption increases French labor supply. The effect of the transfer on investment (not shown in Figure 4) is more complex. Investment in the non-traded sector falls, because the fall in domestic consumption reduces non-traded output. But investment in the export sector increases, because the increase in employment increases the return to capital in this sector. The first effect dominates, and investment falls.

The full impact of the transfer on the terms of trade in the dynamic economy is attributable to a combination of shifts in world demand from French to German and other foreign consumers, and to an expansion in the relative supply of French to rest-of-world exportable goods. To give some insight into the factors involved, we investigate some departures from the baseline calibration. First, we eliminate home bias in preferences, setting $\mu = 1$. This case is shown in the dotted lines in Figure 4. This leads to a significantly lower response of the terms of trade – a 3 percent deterioration, compared to 6 percent in the baseline model. This deterioration arises for two reasons. First, the negative wealth effect of the transfer causes an increase in labor supply which raises French export output, causing a fall in its relative price.[5] Second, holding overall labor supply fixed, there is a movement of employment out of non-traded goods into the export sector, because of the fall in demand for French non-traded goods. The second channel is by far the most important for the impact of the transfer on the terms of trade.Note that the absence of home bias in preferences has almost no consequence for the paths of output and consumption following the transfer.

The dashed lines in Figure 4 represent the case with zero labor supply elasticity, holding all other parameters constant. This makes little difference to the response of the terms of trade or the trade balance, but has a bigger effect on consumption. Consumption falls by about 4.5 percent rather than 3 percent as in the baseline model.

[5] This theoretical point has also been noted by Obtsfeld and Rogoff (1995).

The reason is of course that total output now *falls* gradually, rather than immediately rising, as an investment decline reduces the capital stock over time.

As a final departure from the baseline model, we examine the effect of setting $\chi = 0$. This eliminates the frictions in international capital markets. The impact of the transfer should now be more comparable to the case of the annuitized transfer in the static model, where the country pays the transfer as an annuitized flow over an infinite time horizon. While our experiment does correspond to a full payment of the transfer over just three years, the ability to access international capital markets without cost allows the country to spread the absorption cost of the payment out over an infinite time horizon.[6] The results are shown in the dot-dash lines in Figure 4. In this case, we see a much smaller, but far more persistent response of all variables. The terms of trade deterioration is approximately three percent, and the trade balance improvement only 1.5 percent of GDP. The rise in output and fall in consumption are about half as much as in the baseline model.

How does the effect of a transfer in the model accord with that seen in the historical data following the French indemnity payments? Figure 5 superimposes the baseline results from Figure 4 (with a change of scale) on the historical sample data from France. The data for real GDP per capita, the terms of trade, and real consumption per capita are de-trended for the 1860-1880 period, and the data shown represent deviations from trend. The terms of trade may be stationary, in principle, but Figure 2 shows that there was an upward trend in the terms of trade for France over this period. Our aim is not to explain this trend, but rather the deviations that may be attributable to the transfer. For the net export share, we also de-mean the series for the 1860-1880 period.

Figure 5 establishes that the baseline model generates a deterioration in the terms of trade that resembles the cyclical movement in the French terms of trade after 1871

[6] Note that there remain two differences between this case and the static model. First, output is endogenous through labor supply and capital accumulation. Second, the world real interest rate also is endogenous, because, while France has a small share in the world economy, it is not a pure small economy in the capital market as in the static model.

quite closely. Both in the data and the model, the terms of trade deteriorate by about 6 percent, although the maximum terms of trade deterioration occurs slightly earlier in the model than in the data. In the model, this terms of trade deterioration is very persistent, because it is associated with persistently lower consumption and persistently higher output in France, as the economy experiences a lower ratio of net foreign assets to GDP, after selling assets to finance the transfer. In the data, the terms of trade falls back to its mean level within 4 years.

The movement of net exports in the data is also quite accurately captured by the model. The net export ratio rises by about 3 percent. However, the timing is slightly non-synchronous. The model predicts an immediate increase in 1871, as the transfer takes effect. In the historical data, there is a dip in the net export share in 1871, but this is reversed in 1872, and there is a strong trade surplus for the next four years. Again, due to consumption smoothing, the trade surplus in the model is more persistent than that observed historically.

In the model, the movements of consumption and output following the transfer are quite unlike the historical ones. In the historical sample, consumption and output are 11 and 10 percent respectively below their mean levels in 1871. In the model, the effect of the transfer is to reduce consumption by about 3 percent, and *raise* output by about 1.5 percent. Output rises due to the wealth-induced expansion in labor supply. The fall in consumption is muted by the presence of international capital markets.[7]

How would the alternative parameterizations of Figure 4 affect the comparison in Figure 5? Eliminating the home bias parameter in preferences would have a negligible effect on the output, trade balance, and consumption response, but would lead to a much smaller, and counterfactual, terms of trade deterioration. Eliminating the endogenous response of labor supply on the other hand would have little implication for the terms of trade or the trade balance, but would allow consumption to fall by more,

[7] We also found that the transfer had little ability, on its own, to explain the path of investment. The fall in investment in 1870-71 was far greater than implied by the transfer.

thus improving the comparison in this respect. In the analysis below, however, we argue that the presence of other shocks can help explain the consumption response, even in the baseline model. Finally, eliminating the risk premium term significantly worsens the comparison for all variables, as consumption, the terms of trade, and the trade balance fall by less, and all variables are much more persistent than is apparent in the sample data. Thus, the adjustment to the transfer implied by a purely frictionless international capital market (or the annuitized transfer experiment in the static model) seems not to accord well with the historical experience.

While applying the transfer in the model produces reasonably realistic paths for the terms of trade and the trade balance, the discrepancy between the model and historical sample with respect to the paths of output and consumption suggests that other shocks are missing. We turn to this topic in the next section.

7. Shocks

Like many transfers, the Franco-Prussian War indemnity did not take place in a placid macroeconomic era. During 1870 France experienced a sharp increase in government spending as its armies (first imperial, then republican) were mobilized. It also experienced the economic disruption of the siege of Paris by the Prussian army, the occupation, the Commune in 1871, and the loss of Alsace and Lorraine. To isolate the effects of the transfer, we need to control for these shocks.

The work of economic historians allows us to rule out certain shocks. First, tariffs did not change significantly in either France or its main trading partners during the early 1870s. Smith (1980) and Verdier (1994) have analyzed the political basis for this stability of French commercial policy. France had liberalized trade with Great Britain after 1860 under the terms of the Cobden-Chevalier treaty. During the 1860s, France signed similar treaties with other countries, and Napoleon III issued decrees to abolish import duties on most primary products. And free trade continued after 1870 under the Third Republic. Similarly, protection was not a major tool for Bismarck until 1879.

Second, monetary policy also was not a source of shocks. During this period

France suspended gold convertibility from August 1870 to December 1877, but in fact maintained a fixed exchange rate, with the franc rarely departing from its gold parity value. Thus, we do not model *differential* monetary policy as a source of dynamics.

However, further work may be needed on the *joint* monetary stance of France, Germany, Britain, and their trading partners in the mid-1870s. Flandreau (1996) carefully documented the steps by which Germany left the silver standard and France left bimetallism in favour of gold, as did the United States. This process led to correlated monetary changes across countries and worldwide deflation after 1872 as silver was demonetized. Although the indemnity payments were completed by September 1873, their macroeconomic effects may be entangled with the effects of this monetary regime change. We do not view the transfer as a *cause* of this change in monetary regime. Although Germany used some of the proceeds of the indemnity to acquire gold, France also demonetized silver while paying the transfer.

Third, we also considered – but ruled out – shocks from the rest of the world, which would affect France through foreign GDP, prices, or interest rates. As a check on this possibility, we constructed an index of rest-of-world real GDP for 1860-1880. Maddison (2003) tabulated real GDP in 1990 dollars for Germany, Italy, the UK, the US, and other countries. His US series begins in 1870, so we rescaled the Johnston-Williamson (2004) `eh.net` series for the missing entries for the 1860s. We then summed the series for these four countries. The resulting measure of rest-of-world real GDP yielded no evidence of a business cycle in the early 1870s that would reflect an omitted shock. Nor was there a significant fluctuation in British interest rates during this period.

Our focus thus turns to shocks to two key, domestic, real variables: French government spending and productivity.

7.1 Government Spending

French government spending, shown in figure 3, rose from 793 million francs in 1869 to 1445 million francs in 1870 and 1897 million francs in 1871 before falling back to 925 million francs in 1872. To include this shock to government spending in the model, we first linearly detrend real government spending *per capita* for 1860-1880, then construct percent deviations from trend, denoted $\{\tilde{g}_t\}$. Our first measure of the fiscal shock is simply this series. According to this measure, any deviation from the trend comes as a surprise, and does not lead to a forecast of future deviations from the trend.

Our second measure of the shock is constructed using a linear projection:

$$\tilde{g}_t = \bar{g} + \rho_g \tilde{g}_{t-1} + v_t. \tag{30}$$

The estimate of ρ_g is 0.32, though its standard error – with only twenty annual observations – is 0.22. The shocks now are measured as the series $\{\hat{v}_t\}$. By removing the component of $\tilde{g}_t$ that is predictable at time $t-1$ we allow for some forecasting by economic actors around the trend. The empirical persistence measure, $\hat{\rho}_g$, is known to the forward-looking actors in the model. According to this second measure, once a surprise $\hat{v}_t$ occurs, agents also revise their forecasts for $\tilde{g}_{t+1}$ and beyond.

In practice, the series $\{\tilde{g}_t\}$ has a single spike during 1870 and 1871, so the two series are quite similar. With the second measure, there is a smaller shock in 1871, because a relatively high value is expected given the rise in spending in 1870. With the second measure, there also is a larger negative shock in 1872, because this measure builds in some persistence to forecasts. But given the limited persistence in the actual $\{\tilde{g}_t\}$ series, these differences are not large and so the two measures lead to very similar effects in the model.

Figure 6 illustrates the impact of government spending shocks in the model, using the second measure of fiscal shocks. As is to be expected, the big shocks take place at the time of war, in 1870 and 1871. Output rises because of the effects of the fiscal expansion on labor supply. The government spending shock directly crowds out consumption. Output is 1.4 percent above trend in 1871, and consumption is 1.25 percent below trend. The rapid fall in government spending after the war means that these movements in output and consumption are quite temporary. The direct expansion in demand for domestic goods leads to an improvement in the terms of trade. The net export to GDP ratio deteriorates in 1870 and 1871, but then recovers as government spending falls.

While the wartime increase in government spending was very large, the overall impact on the economy – reflected in the vertical axis units in Figure 6 – is quite small, because the initial size of government in the economy is less than 5 percent of GDP. When we compare the impact of the government spending shocks to the historical sample (shown in Figure 5), we see that government spending can play only a minor role in explaining the macroeconomic variation in aggregates for France. Moreover, the extent to which government spending movements can account for the residual components of macro fluctuations unexplained by the transfer differs across variables. Government spending may partly help explain the greater fall in consumption than is implied by the transfer, but with respect to GDP, the impact of government spending increases the discrepancy between the model and the historical sample.

We lack a full decomposition of government revenues and so have adopted the government budget constraint (24) and assumed lump-sum taxes. Partial revenue data catalogued by Mitchell (1998, table G) show that increases in excise and registration taxes accompanied the payment of the indemnity. Fontvielle (1976) provided annual public accounts – showing the budget deficit widening during the war and indemnity period – but no information on tax rates or changes in them. This lack of tax rate data prevents us from studying the effects of the financing plan, along the lines originated by Ohanian (1997) for the twentieth-century US. Although the dynamic effects of the war and transfer in this model would be affected by the pattern of distorting taxes used to finance them, our findings probably would not be significantly different with distortionary tax financing given the small size of the government sector.

A final reason why fiscal shocks may not have had a large effect on the terms of trade is that government spending rose and then fell in Germany, just as in France. Our model is, appropriately, not one of a small, open economy. Although we do not include this German shock, it would partially offset the effects of the French fiscal shock on the terms of trade and net exports.

7.2 Productivity

The second shock we study is based on an attempt to infer the movement in total factor productivity (TFP) in both sectors of the French economy. Suppose that the aggregate production function now is:

$$z_t k_t^{\alpha} (h_t \xi^t)^{1-\alpha}, \tag{31}$$

where we do not distinguish between sectors, because they have the same capital share ($\alpha = \kappa$) in the calibrated model and because we do not have separate factor input data by sector. The technology now includes labor-augmenting productivity that grows at constant rate ξ and a stationary, random, productivity shock z_t.

In fact, we do not have factor input data even for the aggregate economy. To approximate these components of productivity change, we therefore apply two features of the model to the data. First, Lévy-Leboyer and Bourguignon (1990) provide annual data on capital consumption or depreciation. In the model, this series is simply δk_t, so we multiply it by the calibrated value $\delta^{-1} = 10$ to provide an estimated time series for k_t. Second, with competitive factor markets, the real wage satisfies:

$$w_t = (1 - \alpha) \frac{y_t}{h_t}. \tag{32}$$

We use the real wage series and the calibrated value of α (0.64) along with real output to solve for an estimate of the labor input, h_t. Finally, the productivity terms can then be found from the Solow residuals:

$$z_t (\xi^t)^{0.64} = \frac{y_t}{k_t^{\alpha} h_t^{1-\alpha}}. \tag{33}$$

This scheme for isolating productivity shocks allows for changes in labor supply, such as those predicted by the theory in response to the transfer or fiscal policy.

This procedure is an imperfect method of estimating supply shocks by combining output, depreciation, and real wage data. The method involves ignoring problems of labor market frictions which would make the real wage an unreliable measure of marginal productivity, or variable capacity utilization, which would be conflated in a measure of z. There are no data on employment or on utilization that we could draw on. In addition, we do not separately model the partial destruction of the capital stock during the war, since we have no data on this, and most of the French capital stock was probably outside the area of hostilities. For these reasons, a modest interpretation of the estimated z series as 'supply-side shocks' may be appropriate.

In fact, the estimated z (see below) tracks output quite closely, as is the case in modern growth accounting exercises. This means that the results would be very similar if we instead assumed an endowment economy, in which the path of output is taken as given and the model makes predictions for the other three paths. Equivalently, endogenous labor supply in response to productivity shocks plays little role independently in the model. From a modelling point of view, we find it more appealing to proceed as we do, using a proxy measure of supply or productivity shocks, rather than taking output itself as given, since by doing so, we can incorporate endogenous employment and investment explicitly into the dynamic model.

The implied capital and labor series, along with real output (not in *per capita* terms), are shown in Figure 7 for 1820-1913. Notice that the labor input declines in some years during the 1870s and 1880s. This evidence is consistent with the population data in cited in section 3 and with the economic history, which emphasizes France's very slow or even negative population growth late in the nineteenth century. Table 3 shows growth accounting for France during the twenty years before and after the Franco-Prussian War. The slowdown during the 1870s and 1880s is well-known. Three-quarters of the slowdown in output growth is due to the decline in labor input growth. Despite our indirect identification of $\{h_t\}$, this finding again is roughly consistent with the economic history, which stresses France's early experience of declining birthrates and little immigration during this period. This consistency gives us some confidence in the implied, residual measures of productivity.

The estimate of the growth rate of labor-augmenting productivity is $\hat{\xi} = 0.00493$ or 0.493% per year. The percentage deviations from trend are simply $\tilde{z}_t = \ln z_t$, because the trend in measured productivity is captured by ξ. The lower panel of Figure 7 also illustrates de-trended output and the measured $\tilde{z}$. As noted above, $\tilde{z}_t$ behaves much like output until after the war, when $\tilde{z}$ recovers more strongly than y, a reflection of real wage growth. Some of the fluctuations in this productivity measure are readily matched with other evidence on productivity. For example, $\tilde{z}_t$ falls in 1870, which saw a severe winter, and rises in 1872, which saw good harvests in France.

Figure 8 shows the effects of the productivity shocks in the model. These are introduced in the following way. We estimate a process

$$\tilde{z}_t = \bar{z} + \rho_z \tilde{z}_{t-1} + u_t, \tag{34}$$

over the 1820-1869 period, where the estimates are $\bar{z} = 0.305$ and $\rho_z = 0.897$. Beginning in 1860, and normalizing so that $\tilde{z}_{1859} = .305/(1 - 0.897)$ (which amounts to de-meaning the series for this sub-period), we derive a series of productivity shocks $\hat{u}_t$. We subject the model to these shocks, assuming persistence of 0.897, as in the estimated process.

Figure 8 also overlays the historical data for GDP, the terms of trade, the net export ratio, and consumption with the series predicted by the model with productivity shocks alone. The key feature of this figure is that both observed GDP and consumption are quite well tracked by the model. This is of particular interest because these were the series not well explained by the transfer shock. In particular we found that GDP fell substantially in 1871 while the model with the transfer as the only shock predicted a small increase in GDP. According to Figure 8, the resolution lies in the occurrence of a large negative productivity shock in 1871. Likewise, the much larger fall in consumption than predicted by the transfer alone can also be substantially explained by the size of the productivity shock in 1871.[8]

Meanwhile, the model driven by productivity shocks alone fails to track the terms of trade and trade balance well. The key discrepancies are in the 1870-1873 period.

[8] We also computed the results for Figure 8 under the assumption of fixed labor supply, so that the measured z series is very close to an exogenous output shock. The results are very close to those in Figure 8.

But this is exactly the time of the transfer. We next put all three shocks together to study the extent to which the model can reconcile theory and the historical evidence.

7.3 Complete Sample Paths

Figure 9 illustrates the sample paths for the model when it is subjected to shocks to the transfer, government spending, and productivity, measured as described in the previous sections. The figure also illustrates the sample paths that are implied by the model in the absence of the transfer, but including both government spending and productivity shocks. Finally, we include the historical sample paths.

The figure illustrates the extent to which the transfer of 1871-1873 can help to explain the behavior of the French economy during this period. In the absence of the transfer, it is clear that the model does a very poor job of explaining the historical paths of the terms of trade and net exports for 1871-1873. But with the transfer, the size and timing of movement both of these variables are quite well explained. In particular, the net export series predicted by the model is remarkably close to that in the data. In the model without government spending and productivity shocks, the transfer alone tends to make net exports rise too early, relative to the sample path, but the combination of the transfer with a large negative productivity shock causes the rise in net exports in the model to be delayed until 1871, exactly as in the sample path. In contrast, the terms of trade response in the model is somewhat delayed relative to the historical sample, again due to the negative productivity shock in 1871. However, the size of the terms of trade adjustment is exactly as in the sample.

The reason for the delay in the terms of trade deterioration in 1871, in the model, is the large fall in export-good production associated with the negative productivity shock in both sectors. The fall in export-good output tends to reduce s, while the impact of the transfer tends to increase s. The end result is that s in the model hardly moves at all in 1871, while in the sample s rises sharply. In fact, the movement in the terms of trade is better explained in the model without productivity shocks. One possible explanation for this is that productivity shocks were concentrated in the non-traded goods sector. Figure 10 repeats the exercise of Figure 9, but assuming now that productivity shocks occur only in non-traded goods. In this case both the size and timing of the terms of trade response in the model are strikingly close to those of the sample path. At the same time, the movement in the net export ratio remains close to that in the the sample. In fact, Figure 10 shows quite close accord between the model and the sample path for all variables.[9]

An advantage of the full dynamic model is the ability to track the paths of macroeconomic variables in response to the transfer and other shocks. In terms of providing a quantitative accounting for the importance of the transfer, this is a significant improvement over the static trade model of section 4.

8. German Evidence

A lack of macroeconomic data for Germany precludes our comprehensively testing the model by applying it there. For example, there is no series for the German terms of trade prior to 1880 and no series for the current account prior to 1870. Hoffmann (1965) and Spree (1977) have constructed other macroeconomic aggregates at annual frequency, and attempted to adjust for the changing borders of the German state. Hoffmann's estimates of national product and its components have been criticized by Fremdling (1995), but no alternative measures are yet available. Appendix B again provides details of the measurements and data sources we adopted.

To see what the theory predicts for Germany, first imagine inverting figure 4, to show the effects of a transfer on the recipient rather than the donor. The theory implies that output falls relative to trend, because German labor supply falls as a result of a wealth effect. And consumption is predicted to rise because of the same wealth effect. In addition, the trade balance deteriorates, because part of the transfer is lent abroad, while the terms of trade improve.

[9] The transfer does not play a large role in investment behavior. While not illustrated, we constructed the model's implications for investment, with and without the transfer. The simulated investment path broadly follows the historical sample path, but compared with the measured productivity shock, the transfer has a very minor effect on investment. With the transfer, investment is slightly lower, as, through the endogenous risk premium, the real interest rate rises when the trade account goes into deficit.

We inspected expenditure shares of GDP from the Hoffmann data. The share of net exports in GDP deteriorated in the early 1870s, as the transfer was being paid, and as predicted by the theory. While no terms-of-trade series is available, Zussman (2002) has constructed a German real exchange rate, and found a real appreciation from 1870 to 1873, which again is consistent with theory. On the other hand, the consumption share of GDP fell by 4-5 percentage points, in clear contrast with the theory's prediction of an increase in this share. Instead, the share of investment spending in Germany rose.

To try to explain these facts, we again consider other shocks. The share of government spending has two peaks, corresponding to the wars against Austria-Hungary (1866) and France (1870). According to the theory (as in Figure 6), the increase in spending during the Franco-Prussian War should have caused output to rise, and consumption to fall as a share of output. But then the postwar decline in government spending is predicted to lead to a decline in output and a rise in the consumption share. In Germany, unlike France, both fiscal contraction and the transfer are predicted to lead to increases in the consumption share. So allowing for the effects of fiscal policy deepens the puzzle of falling consumption and rising investment shares.

Finally, Germany also experienced rapid output growth from 1871 to 1873, accompanied by a stock market boom. Solow residuals (measured as in section 7.2) reveal the same pattern. The model predicts that consumption should rise less than output in response to positive shocks to productivity, so that the share of consumption falls. Our preliminary conclusion is that the effects of productivity improvements may have offset the effects of fiscal policy and the transfer.

In sum, the early 1870s saw rapid output growth and an investment boom in Germany. Our research suggests that these cannot be attributed to the transfer. Instead, they may have been caused by improvements in total factor productivity. Candidate sources for this growth include liberalized rules of incorporation (in 1870), improvements in banking, efficiency gains from an expanded customs union, and railway unification.

9. Conclusion

The transfer problem is of interest for several reasons. It has played a large role in the development of theoretical models in international economics. In economic history, a range of economic effects have been attributed to transfers, without much formal modelling. Transfers can be viewed as large-scale experiments with which to test models of the terms of trade. And models of transfers are needed to predict the effects of current transfers, such as development aid.

Our work has shown how the predicted effects of a transfer depend on (a) international borrowing and lending, (b) supply-side responses, and (c) the degree of home bias in preferences. These three characteristics could also be taken into account in assessing contemporary transfers. For example, the response of a recipient's terms of trade to a transfer made by a government or international organization or to the repatriation of labor income may depend on the openness of private capital markets.

Our results indicate that a dynamic, general equilibrium model of the current account and terms of trade, which combines the transfer with historical changes in government spending and in productivity, does well in matching the key features of French macroeconomic history after the Franco-Prussian War. This match holds even though (a) we have sought to match sample paths, rather than the weaker criterion of matching moments, and (b) we have studied the nineteenth century using some parameter values from the twentieth century. Although we have tried to calibrate parameters (such as home-bias μ and country-size ω) with auxiliary, nineteenth-century data sources where possible, we have not selected parameter values to improve the fit of these paths.

Given the great size of the transfer, one might expect its effects to be glaringly obvious in the macroeconomic data, to the point where one need not even try to measure other shocks. Popular history often made this assumption, and attributed large economic effects to the indemnity. On the contrary, we find that changes in aggregate productivity clearly are needed in order to fit French and German macroeconomic history, especially with respect to the movements of output and consumption. This finding is striking evidence of the importance of international capital markets in the late nineteenth century.

Appendix A: Terms of the Treaty of Frankfurt

Article VII

A payment of five hundred million francs will take place within the thirty days following the re-establishment of the French government's authority in Paris. A billion francs shall be payable within the current year, and a half-billion at 1 May 1872. The remaining three billion francs will be payable by 2 March 1874, as stipulated in the preliminary peace treaty.

After 2 March of the current year, the interest on these three billion francs will be payable on 3 March each year, at a rate of five percent per year. Any part of the remaining three billion francs that is paid in advance will cease to accrue interest from the date of the payment.

All payments may be made only in the major commercial cities of Germany and are payable in gold, silver, notes of the central banks of England, Prussia, the Netherlands, or Belgium, bills of exchange, or cashable notes.

In France, the German government has fixed the value of the Prussian thaler at 3.75 francs. The French government accepts the conversion of the two countries' currencies at this rate.

[Translated by the authors. Our calculations include the separate Paris indemnity but not the interest payments at 5 percent, for the latter were roughly offset by a payment to France for railways in Alsace and Lorraine.]

Appendix B: Data Sources and Definitions

France

Annual data for France are from Lévy-Leboyer and Bourguignon (1990). The following table gives the precise definitions of the measures we use, with the corresponding source in their monograph:

Measure	*Table*	*Series*
nominal GDP	A-III	1
net exports	A-III	5+6-7
investment	A-III	4+8
consumption	A-III	2
government spending	A-III	3
net foreign income	A-I	8
import prices	A-VI	4
export prices	A-VI	5
cost of living	A-IV	13
real wage	A-IV	14

Annual estimates of French population are from Mitchell (1998, table A5). These coincide with the quinqennial censuses and also reflect the loss of Alsace and Lorraine.

Net foreign assets are from Levy-Leboyer (1977), tableaux X, page 120. The French nominal interest rate is the yield on 3% *rentes*, from Homer (1977) table 25, page 223. The inflation rate is calculated from the cost of living index.

Britain

The foreign nominal interest rate is the yield on 3% British consols, from Homer (1977), table 19, page 196. The British inflation rate is calculated from the Sauerbeck-*Statist* price index from Mitchell and Deane (1962), page 474.

Germany

Annual data for Germany are from Hoffmann (1965) and Spree (1977). The real capital stock (in 1913 marks) is from Hoffmann, table 39. Real consumption, net investment, and government spending (1913 marks) are from Hoffmann, table 249. Real, net national product is from table 103, measured as the sum of output in different sectors. This series is rescaled by splicing it to the series on NNP, measured as the sum of expenditures, from table 249, which begins in 1880. Net investment and NNP are made gross by adding 10 percent of the capital stock series. Real net exports are then found from the national income-expenditure identity.

The real wage index (1900=100) and the index of German share prices are from Spree's tables A3 and A16 respectively.

Volume indexes of exports and imports are found in Hoffmann (tables 129 and 131) and Spree (tables A39 and A40). While these series differ, they both show sharp deteriorations in the volume of net exports after 1871, consistent with the receipt of a transfer.

Rest of World

Rest-of-the world real GDP is the sum of real GDP in 1990 Geary-Khamis dollars for Germany, Italy, the UK, and the US from Maddison (2003) tables 1b and 2b. For the US, data for the 1860s are rescaled measures from Johnston and Williamson (2004).

Table 1: Evidence on the Static Model

Transfer (% GDP)	Terms of Trade (% change)	Real Consumption (% change)
	Model Predictions (ω = 0.165 μ = 6.5)	
7.24%	13.22%	-8.11%
22%	40.34%	-26.51%
1.1%	1.99%	-1.21%
	France (1871-72 and 1871-74)	
7.4%	1.5%	11.7%
22%	2.9%	8.1 %
	France (1870-71 and 1870-73)	
7.4%	4.1%	-7.6%
22%	7.5%	0.2%

Notes: ω is the French share of world GDP; μ captures the home bias in the consumption of traded goods; non-traded goods prices comprise a share γ=0.5 of the price index; the elasticity of substitution between traded and non-traded goods is θ=.75; the elasticity of substitution between exports and imports is λ=1.5. Consumption is measured on a per capita basis. Appendix B gives the sources for the historical data.

Table 2: Calibration

Parameter	Value	Description
σ	1	Inverse of elasticity of substitution in consumption
β	0.94	Discount factor (annual real interest rate is $(1-\beta)/\beta$)
ν	1.0	Inverse of elasticity of labor supply
η	1	Weight on labor supply in period utility
θ	0.75	Elasticity of substitution: traded and non-traded goods
λ	1.5	Elasticity of substitution: import and export goods
γ	0.5	Share of non-traded goods in consumption
μ	6.5	Home bias in traded-goods consumption
α	0.36	Share of capital in export sector production
κ	0.36	Share of capital in non-traded sector production
δ	0.1	Annual rate of capital depreciation (in both sectors)
ϕ'/ϕ''	0.3	Elasticity of q with respect to the investment-capital ratio
χ	-0.01	Elasticity of real interest rate to net foreign assets
ω	0.165	Share of France in world GDP

Note: Parameter values are discussed in sections 4 and 6.

Table 3: Growth Accounting for France

Years	1850–1870	1870–1890
output growth	1.32	0.47
capital contribution	0.60	0.86
labor contribution	0.35	-0.29
productivity growth	0.36	0.50

Notes: Growth accounting uses the production function (31) with exponent α=0.64. Growth rates are average, annual, percentage changes. Data are not in per capita terms.

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Figure 1: French Current Account/GDP

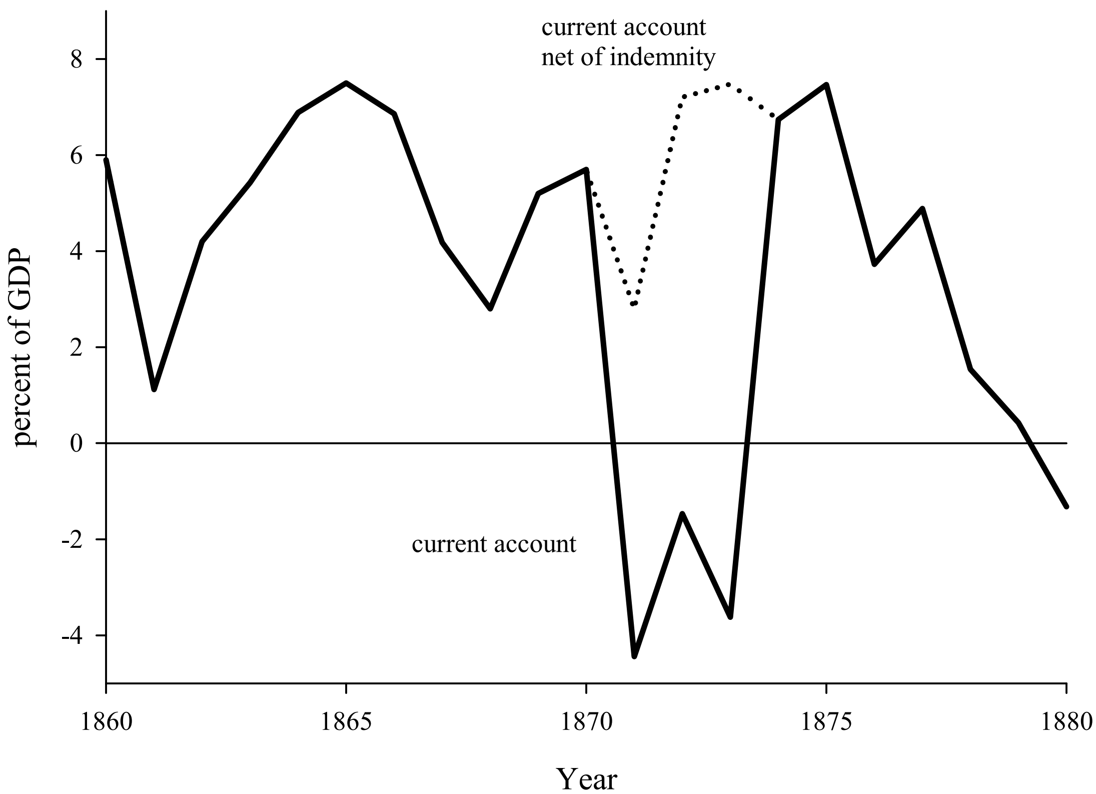

Figure 2: French Terms of Trade and Net Export Share

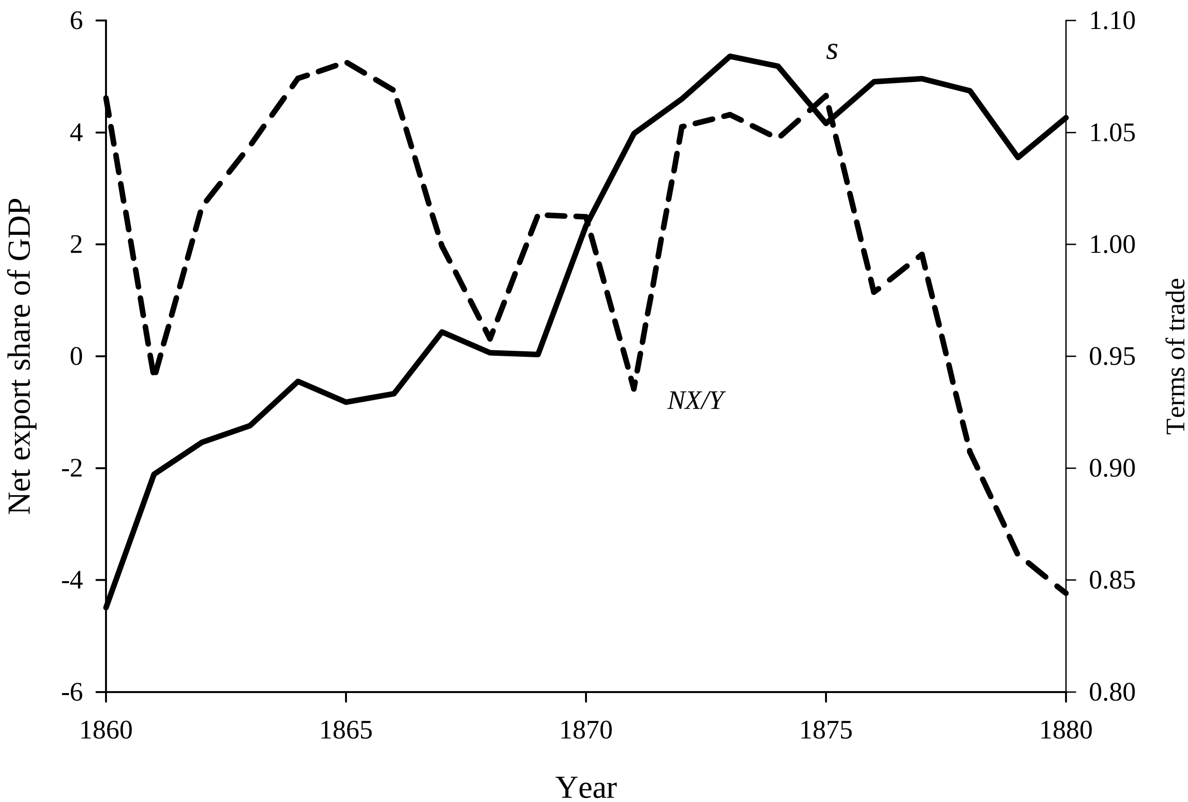

Figure 3: Real output, consumption, and government spending

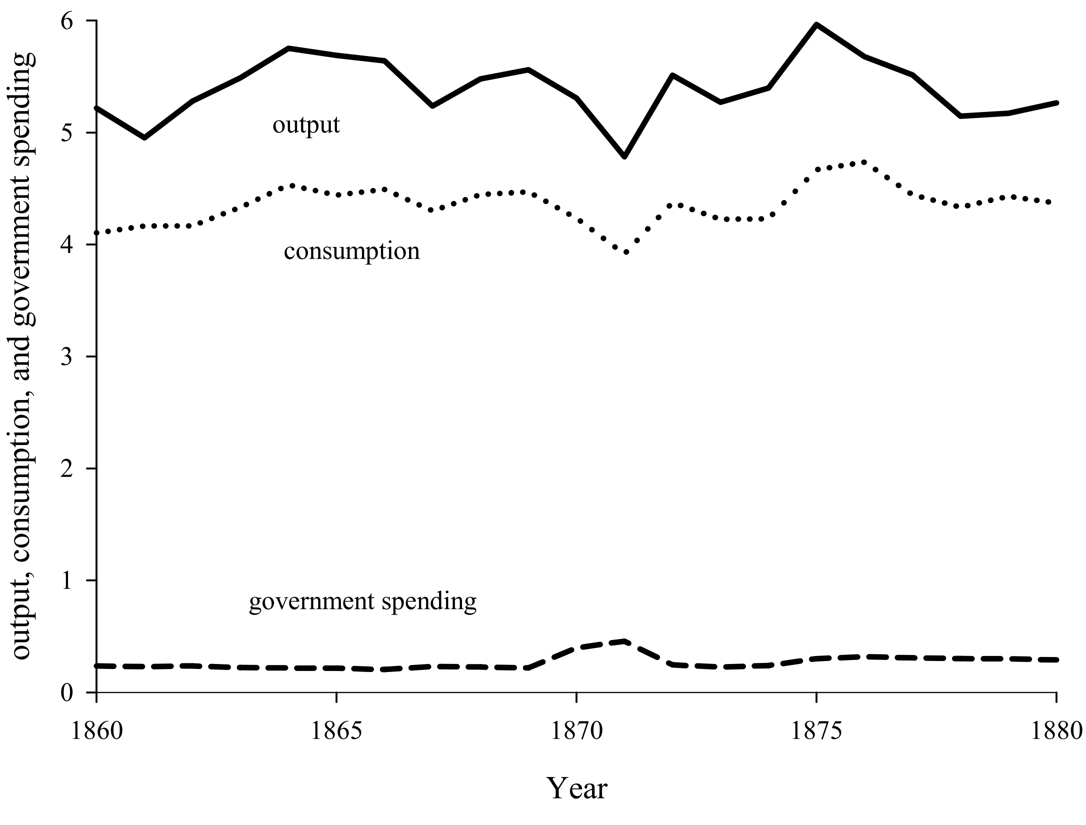

Figure 4: Responses to a Transfer

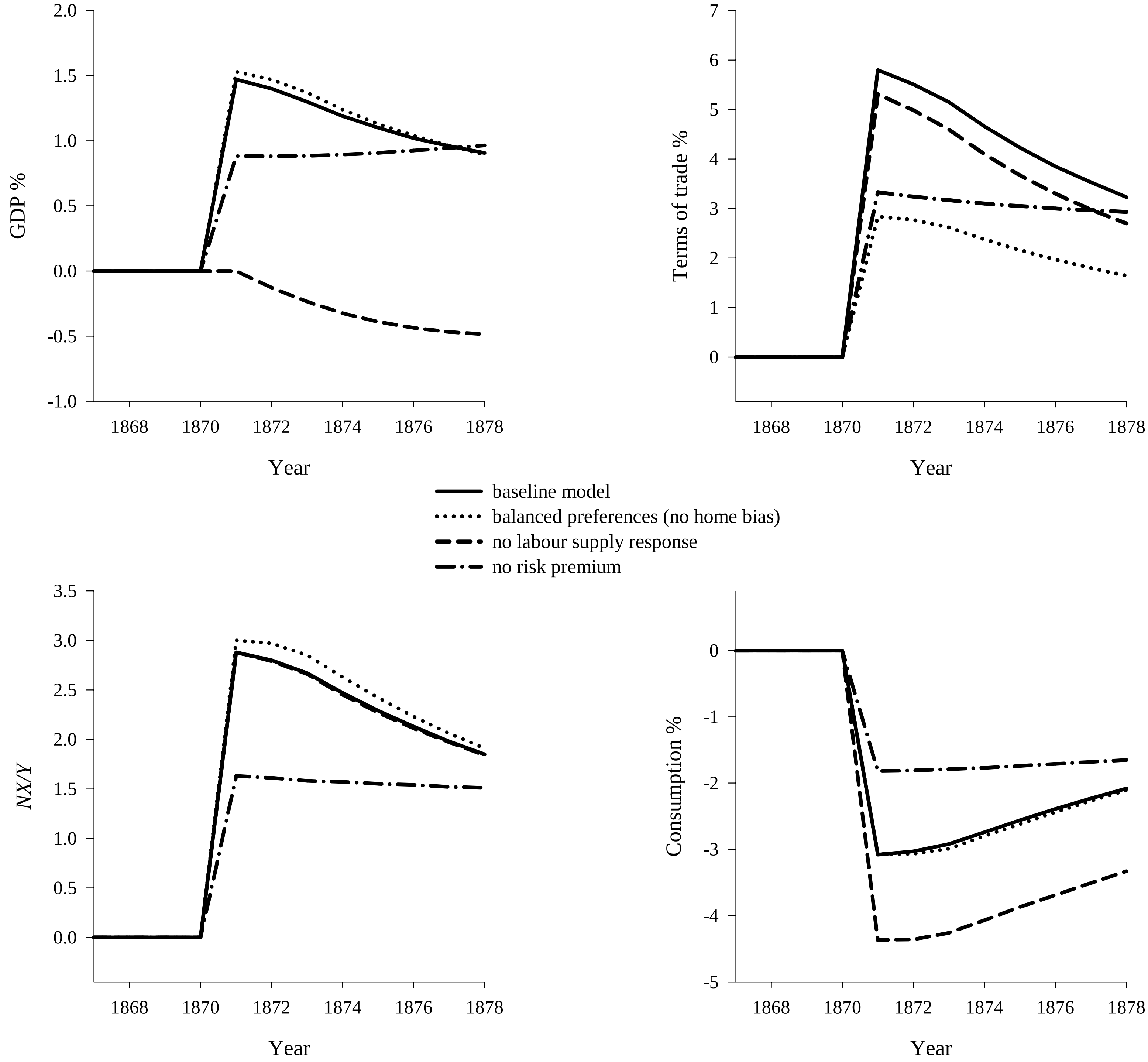

Figure 5: Baseline transfer effects and French history

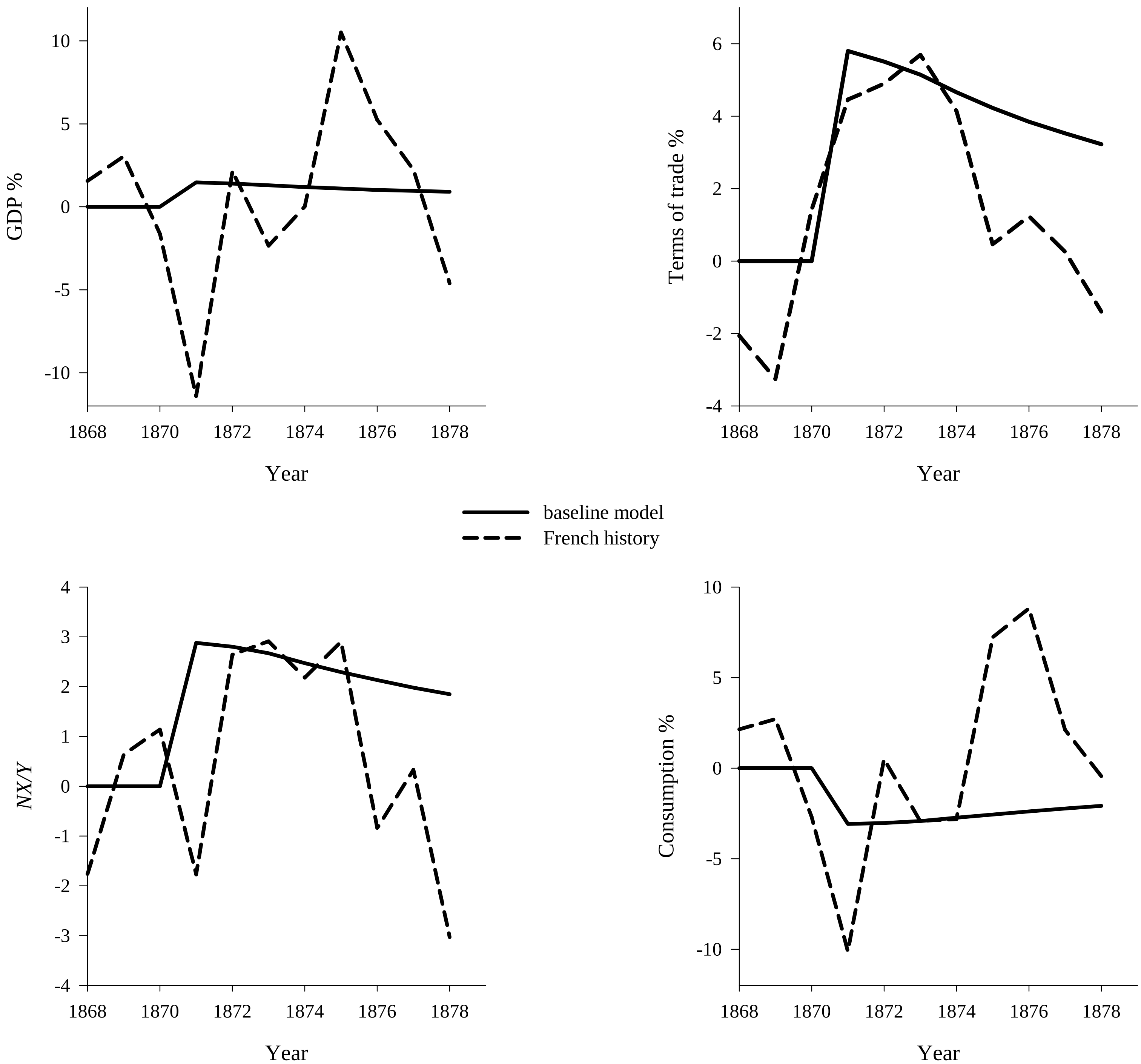

Figure 6: Responses to government spending shocks, baseline model

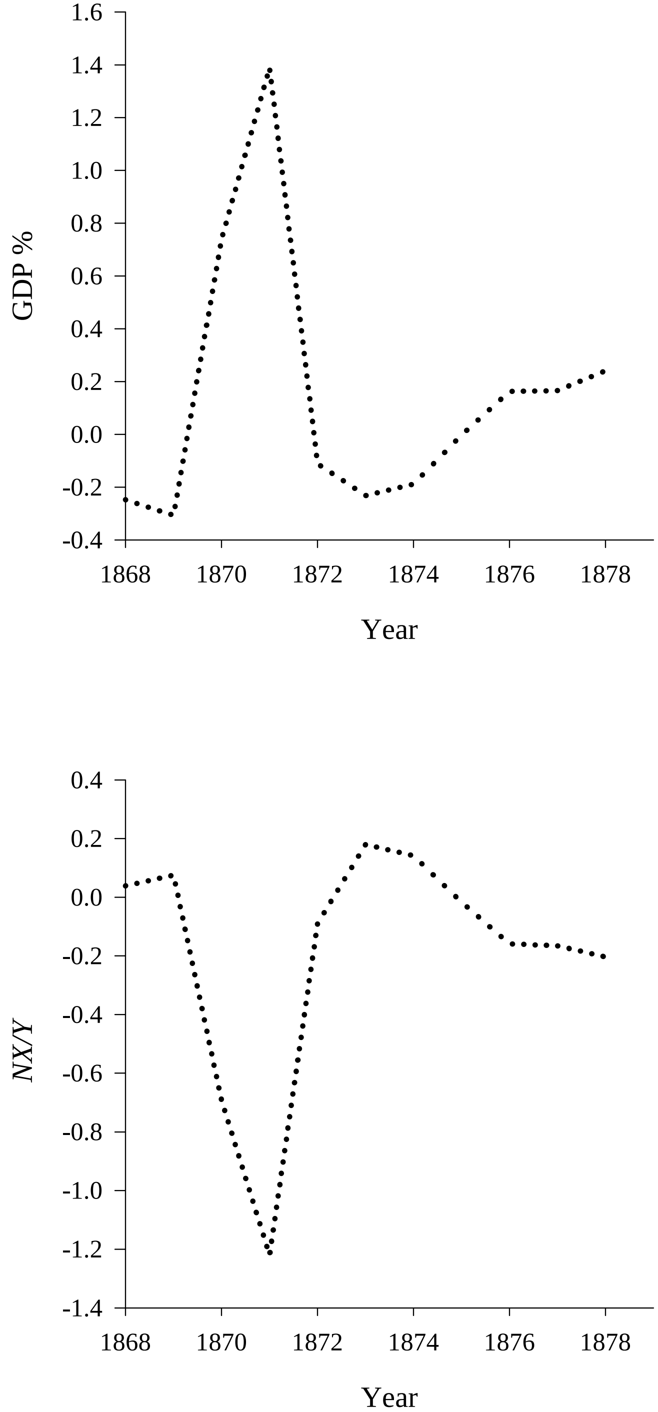

Figure 7: French "Growth Accounting"

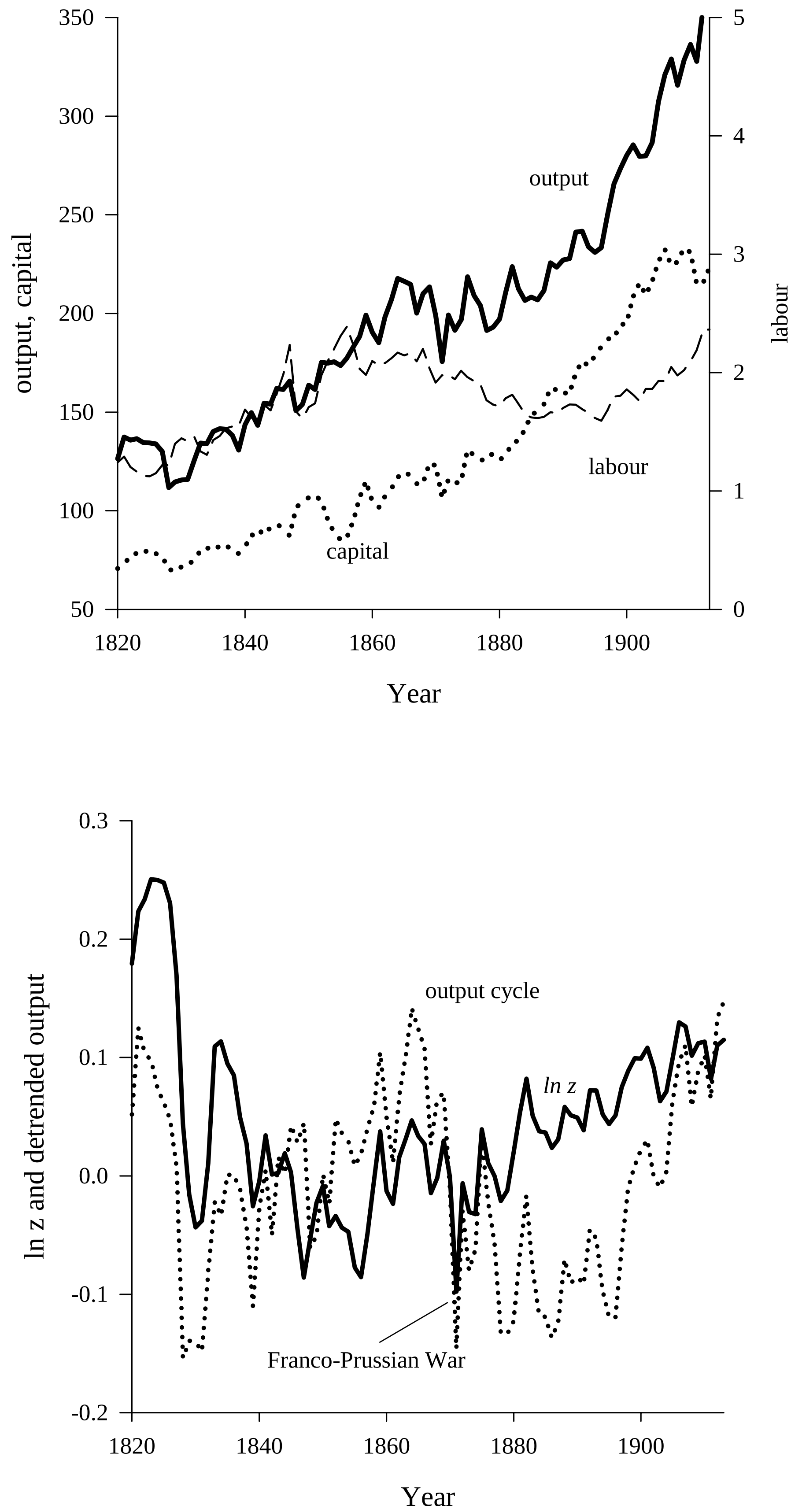

Figure 8: Productivity effects and French history

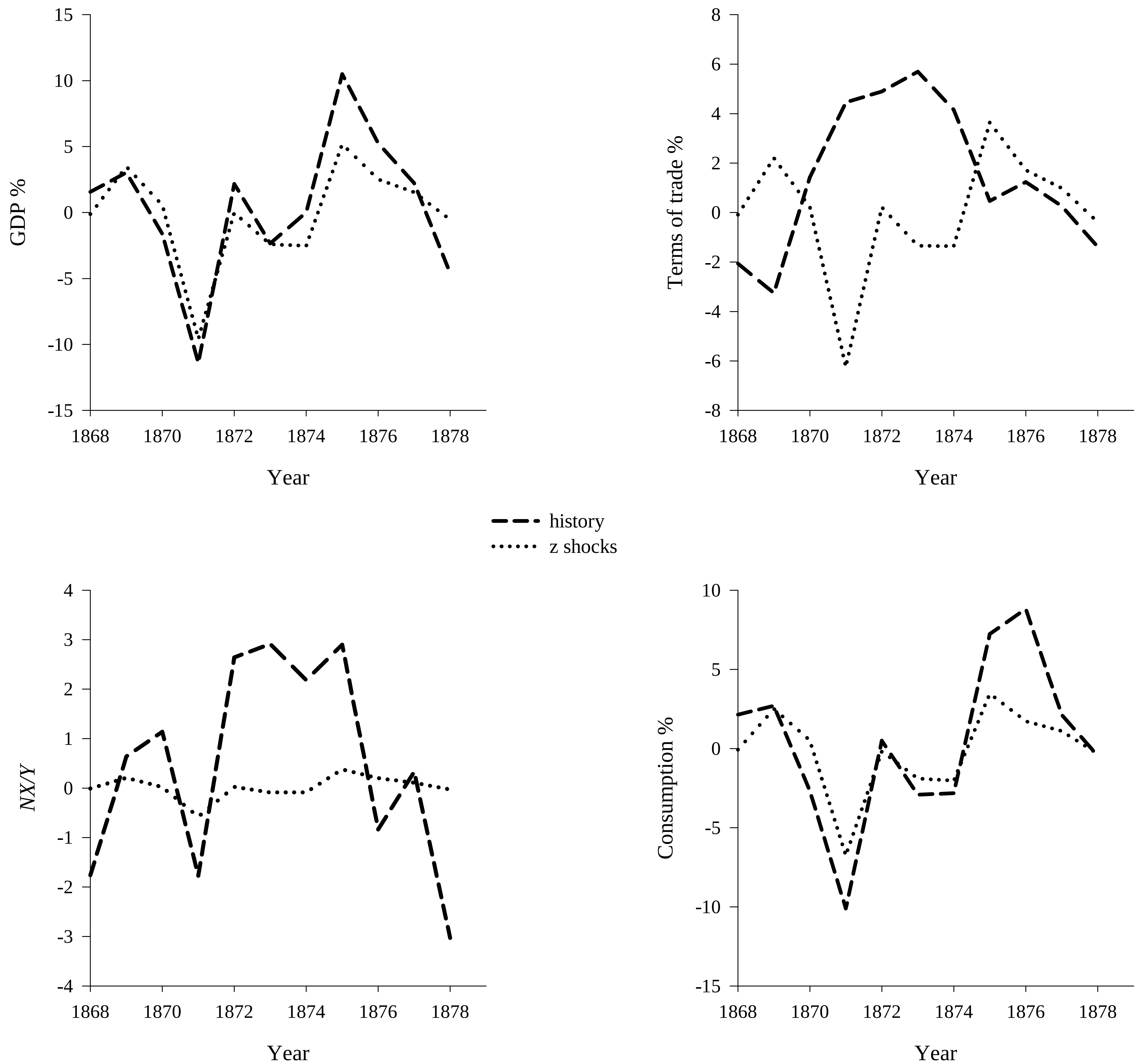

Figure 9: All shocks and French history

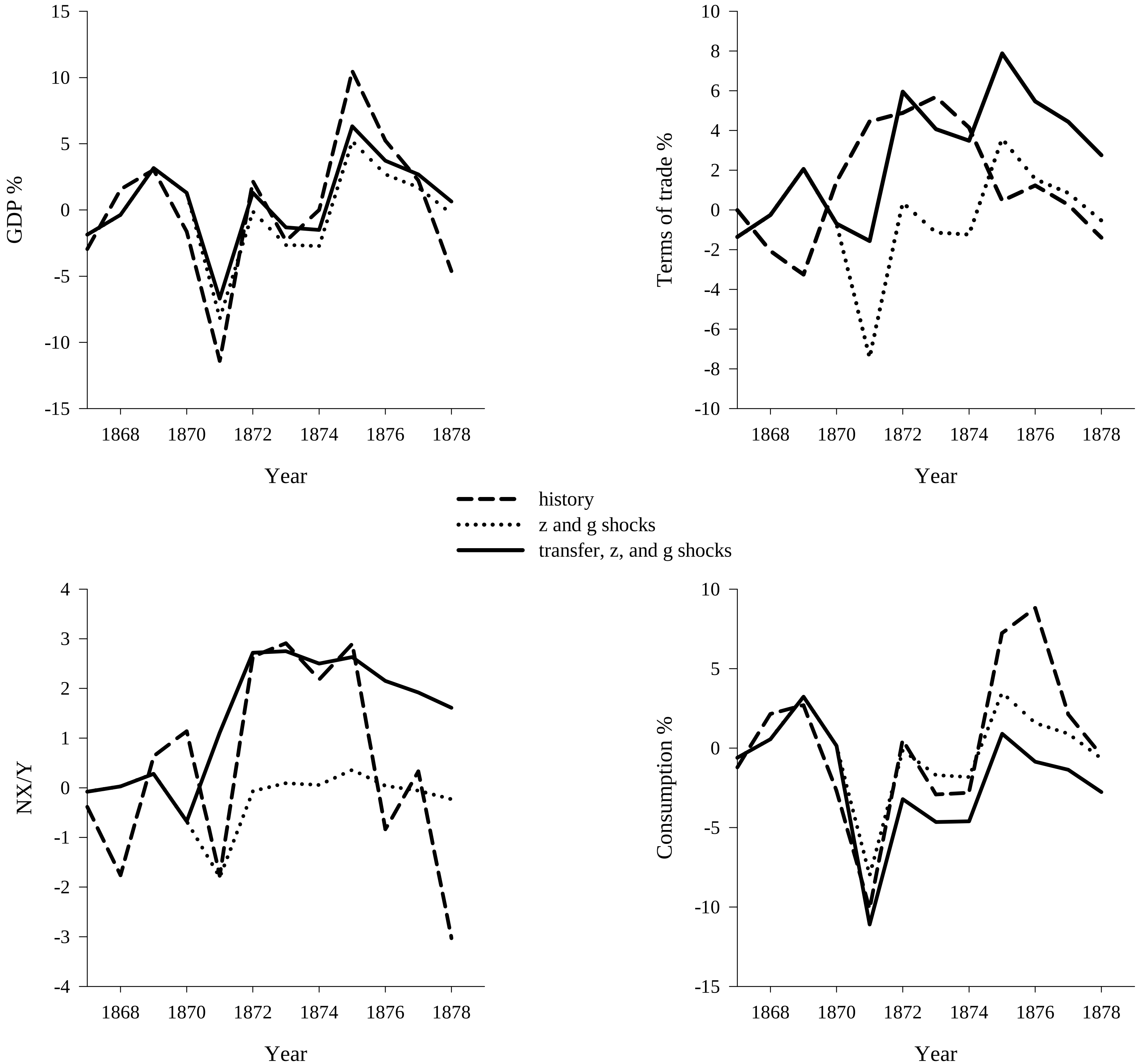

Figure 10: Productivity shocks in non-traded goods